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MONTHLY WEATHER REVIEW

VOLUME 44, No. 2

FEBRUARY, 1916

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NOTICE TO CONTRIBUTORS.

Contributions intended for publication in any given issue of the MONTHLY WEATHER REVIEW (e. g., January) should be in the hands of the Editor before the end of the next following month (e. g., February), if no illustrations are required. When the paper is illustrated, the manuscript and the copy for the illustrations must be submitted much earlier, in order to permit copy being prepared for the engraver by the end of the month.

REPRINTS are made up without covers in the original size and pagination of the REVIEW. They will not be furnished unless specifically REQUESTED WHEN THE MANUSCRIPT IS SUBMITTED.

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CLEVELAND ABBE, jr., Acting Editor.

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FEBRUARY, 1916.

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INTRODUCTION.

As explained in this Introduction during 1914, the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

SUPPLEMENTS to the MONTHLY WEATHER REVIEW will be published from time to time.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports "Climatological Data" for the respective States, Territories, and colonies.

Beginning August, 1915, the material for the MONTHLY WEATHER REVIEW has been prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology.*—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology.*—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere.*

SECTION 4.—*Rivers and floods.*

SECTION 5.—*Seismology.*—Results of observations by Weather Bureau observers and others as reported to the Washington office. Occasional original papers by prominent students of seismological phenomena.

SECTION 6.—*Bibliography.*—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month.*—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto; Meteorological Summary and chart No. 9 of the North Atlantic Ocean for this month in 1915. Owing to the fact that ocean meteorological data are frequently not available for a considerable time after the close of the month to which they relate, the chart and text matter in connection therewith appear one year late.

In general, appropriate officials prepare the seven sections above enumerated; but all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions, that during recent years were prepared by the 12 respective "district editors", are omitted from the MONTHLY WEATHER REVIEW but collected and published by States at selected section centers.

The data needed in section 7 can only be collected and prepared several weeks after the close of the month designated on the title page; hence the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are specially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belén College. Habana.
The Government Meteorological Office of Jamaica.
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, Petrograd.
The Philippine Weather Bureau.

The Weather Bureau desires that the MONTHLY WEATHER REVIEW shall be a medium of publication for contributions within its field, but such publication is not to be construed as official approval of the views expressed.

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SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASUREMENTS DURING FEBRUARY, 1916.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Weather Bureau, Washington, Mar. 22, 1916.]

For a description of instrumental exposures, and an account of the methods of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1916, **44**:2.

From Table 1 it is seen that the monthly means of direct solar radiation intensities for Washington are about normal, for Santa Fe, N. Mex., they are slightly above normal, and for Madison, Wis., they are markedly above. The monthly maxima at Washington and Madison do not differ appreciably from the absolute February maxima for these stations. At Santa Fe they about equal the previously obtained annual maxima for the station.[1] At Madison and Lincoln the highest measurements with air mass 2.0 to 3.0, and at Santa Fe the highest measurements for the month, were obtained on days when the surface water-vapor pressure was at its minimum for the month, as shown by Table 2.

Skylight polarization measurements were obtained at Washington on only three days, and they give a mean of 61 per cent. The maximum, 65 per cent, measured on the 21st, is slightly above the average February maximum.

TABLE 1.—*Solar radiation intensities during February, 1916.*

[Gram-calories per minute per square centimeter of normal surface.]

WASHINGTON, D. C.

Date.	Sun's zenith distance. 0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass. 1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
A. M.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
Feb. 3	.....	.....	*0.82	0.90	0.85	0.78	0.72	0.70	0.67	0.56	.....
14	.....	1.45	1.40	1.32	1.25	1.17	1.08	1.02	0.96	0.90	.....
15	.....	1.36	1.23	1.12	1.06	0.99	0.91	0.85	0.80	0.76	.....
16	.....	.....	.....	.....	.....	.....	0.80	0.75	0.71	.....	.....
19	.....	1.42	1.15	1.07	1.01	0.94	0.88	0.82	0.76	0.72	.....
21	.....	1.51	1.42	1.34	1.26	1.17	1.09	1.03	0.99	0.96	.....
26	.....	1.31	.....	.....	.....	.....	.....	.....	.....	.....	.....
28	.....	1.41	1.31	1.18	1.07	0.99	0.93	.....	.....	0.80	.....
Monthly means	.....	**1.41**	**1.30**	**1.16**	**1.08**	**1.01**	**0.92**	**0.86**	**0.82**	**0.78**	.....
Departures from 9-year normals	.....	±0.00	+0.04	±0.00	±0.00	±0.00	±0.00	±0.00	+0.01	−0.03	.....
P. M.											
Feb. 7	.....	.....	.....	1.14	1.00	0.96	0.90	0.84	0.80	0.77	.....
14	.....	.....	1.36	1.26	1.20	1.11	1.04	0.99	0.95	0.90	.....
15	.....	.....	1.17	1.06	0.84	0.77	0.71	0.66	0.61	0.55	.....
21	.....	.....	1.39	1.15	0.96	0.84	0.76	0.71	0.64	0.59	.....
Monthly means	.....	.....	**1.31**	**1.15**	**1.00**	**0.92**	**0.85**	**0.80**	**0.75**	**0.70**	.....
Departures from 9-year normals	.....	.....	+0.06	+0.01	−0.03	−0.01	−0.02	−0.04	−0.03	−0.06	.....

* Partial eclipse of sun.

[1] See this REVIEW for September, 1915, **43**:440.

TABLE 1.—*Solar radiation intensities during February, 1916*—Contd.

MADISON, WIS.

Date.	Sun's zenith distance. 0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass. 1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
A. M.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
Feb. 1	.....	.....	1.50	1.41	1.33	1.26	1.19	1.12	1.06	0.97	.....
2	.....	.....	.....	1.41	.....	.....	.....	.....	.....	0.85	.....
7	.....	.....	1.55	1.49	1.43	1.37	1.29	1.24	1.20	.....	.....
13	.....	.....	1.45	.....	.....	.....	.....	.....	.....	.....	.....
27	.....	1.60	.....	.....	.....	.....	.....	.....	.....	.....	.....
29	.....	.....	.....	.....	.....	.....	.....	1.07	1.02	.....	.....
Monthly means	.....	**(1.60)**	**1.50**	**1.44**	**(1.38)**	**(1.32)**	**(1.24)**	**1.14**	**1.09**	**(0.91)**	.....
Departures from 6-year normals	.....	+0.09	+0.13	+0.14	+0.16	+0.11	+0.09	+0.14	+0.17	−0.03	.....
P. M.											
Feb. 1	.....	.....	.....	1.44	1.36	.....	.....	.....	.....	.....	.....
7	.....	.....	1.57	.....	.....	.....	.....	.....	.....	.....	.....
9	.....	.....	1.36	1.29	1.21	.....	.....	.....	.....	.....	.....
Monthly means	.....	.....	**(1.46)**	**(1.36)**	**(1.28)**	.....	.....	.....	.....	.....	.....
Departures from 6-year normals	.....	.....	+0.09	+0.06	+0.08	.....	.....	.....	.....	.....	.....

LINCOLN, NEBR.

Date.	Sun's zenith distance. 0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass. 1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
A. M.											
Feb. 1	.....	.....	1.52	1.48	1.37	1.11	.....	.....	.....	.....	.....
2	.....	.....	.....	1.29	.....	.....	.....	.....	.....	.....	.....
8	.....	.....	.....	1.25	.....	0.98	.....	.....	.....	.....	.....
13	.....	.....	1.48	1.39	1.30	1.21	1.12	1.04	.....	.....	.....
15	.....	1.53	1.44	1.35	1.25	1.16	1.07	0.97	.....	.....	.....
16	.....	.....	1.36	1.22	1.02	.....	0.96	.....	.....	.....	.....
17	.....	1.47	1.38	1.30	.....	.....	.....	.....	.....	.....	.....
18	.....	.....	1.50	1.43	1.35	.....	.....	.....	.....	.....	.....
19	.....	1.33	.....	1.20	1.09	0.98	0.88	0.80	.....	.....	.....
20	.....	1.49	1.42	1.33	1.25	1.18	1.11	.....	.....	.....	.....
21	.....	1.48	1.34	1.23	1.15	1.06	0.96	.....	.....	.....	.....
23	.....	.....	.....	1.40	1.34	1.27	.....	1.09	1.01	.....	.....
24	.....	.....	.....	1.37	1.28	1.20	1.13	.....	0.98	0.93	.....
29	.....	.....	.....	1.15	.....	0.96	.....	.....	.....	.....	.....
Means	.....	**1.46**	**1.43**	**1.31**	**1.24**	**1.11**	**1.03**	**0.98**	**(1.00)**	**(0.93)**	.....
P. M.											
Feb. 1	.....	.....	1.49	1.42	1.36	1.30	1.23	1.17	1.11	.....	.....
2	.....	.....	1.45	.....	.....	.....	.....	.....	.....	.....	.....
14	.....	.....	1.22	.....	.....	.....	0.85	.....	0.72	0.65	.....
16	.....	.....	.....	1.29	.....	1.07	.....	.....	.....	0.75	.....
17	.....	.....	1.37	.....	.....	.....	.....	.....	.....	.....	.....
21	.....	.....	1.36	1.27	1.20	1.12	1.05	.....	.....	0.87	.....
23	.....	.....	1.42	1.30	1.20	1.12	1.04	0.97	0.89	.....	.....
Means	.....	.....	**1.38**	**1.32**	**1.25**	**1.15**	**1.04**	**(1.07)**	**0.91**	**(0.76)**	.....

SANTA FE, N. MEX.

Date.	Sun's zenith distance. 0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass. 1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
A. M.											
Feb. 1	.....	1.66	.....	1.48	.....	.....	.....	.....	.....	.....	.....
3	.....	1.65	1.54	1.44	.....	.....	.....	.....	.....	.....	.....
8	.....	1.53	1.34	.....	.....	.....	.....	.....	.....	.....	.....
10	.....	1.54	1.49	.....	.....	.....	.....	.....	.....	.....	.....
11	.....	.....	1.43	1.22	.....	.....	.....	.....	.....	.....	.....
14	.....	1.60	1.52	1.44	1.32	.....	1.22	.....	.....	.....	.....
16	.....	1.61	1.49	1.41	1.30	1.27	1.20	1.13	1.07	.....	.....
18	.....	.....	1.35	1.24	1.19	1.16	.....	.....	.....	.....	.....
19	.....	1.59	1.51	1.44	.....	.....	.....	.....	.....	.....	.....
23	.....	1.61	1.52	1.43	1.36	1.27	1.16	1.06	0.99	.....	.....
Monthly means	.....	**1.60**	**1.47**	**1.39**	**1.29**	**1.23**	**1.19**	**(1.10)**	**(1.03)**	.....	.....
Departures from 4-year normals	.....	+0.02	+0.02	+0.03	+0.03	±0.00	±0.00	±0.00	±0.00	.....	.....

TABLE 2.—*Vapor pressure at pyrheliometric stations on days when solar radiation intensities were measured.*

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.			Santa Fe, N. Mex.		
Date.	8 a.m.	8 p.m.	Date.	8 a.m.	8 p.m.	Date.	8 a.m.	8 p.m.	Date.	8 a.m.	8 p.m.
1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*
Feb. 3	2.62	1.88	Feb. 1	0.66	0.74	Feb. 1	0.66	0.91	Feb. 1	0.86	1.02
7	3.81	1.12	2	0.53	0.71	2	0.71	1.37	3	1.52	2.62
14	0.91	1.12	7	0.36	0.51	8	1.96	3.81	8	3.30	2.62
15	0.96	2.49	13	0.86	1.07	13	0.66	1.37	10	2.49	3.15
16	2.16	2.87	27	1.12	1.32	14	1.52	3.45	11	3.00	4.17
19	1.24	1.68	29	1.32	1.32	15	2.16	4.37	14	3.30	1.88
21	2.16	1.45				16	4.37	6.76	16	2.26	2.62
26	3.30	2.49				17	4.75	5.16	18	3.15	3.45
28	1.32	1.45				18	3.45	4.95	19	2.49	2.87
						19	3.99	6.76	23	2.87	3.00
						20	4.37	6.02			
						21	4.17	7.04			
						23	3.15	4.57			
						24	3.99	3.63			
						29	1.68	3.45			

TABLE 3.—*Daily totals and departures of solar and sky radiation at Washington, D. C., during February, 1916.*

[Gram-calories per square centimeter of horizontal surface.]

Date.	Daily totals.	Departure from normal.	Excess or deficiency since first of month.
1916.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Feb. 1	36	−167	−167
2	21	−185	−352
3	283	74	−278
4	313	100	−178
5	199	− 17	−195
6	233	13	−182
7	242	18	−164
8	231	3	−161
9	38	−194	−355
10	275	38	−317
Feb. 11	210	− 31	−348
12	58	−187	−535
13	34	−215	−750
14	405	152	−598
15	381	124	−474
16	308	48	−426
17	260	− 4	−430
18	210	− 57	−487
19	382	111	−376
20	331	57	−319
Decade departure			− 2
Feb. 21	434	156	−163
22	295	14	−149
23	199	− 86	−235
24	12	−276	−511
25	68	−223	−734
26	321	26	−708
27	273	− 25	−733
28	425	124	−609
29	205	− 99	−708
Decade departure			−389
Deficiency since first of year (Gram-calories)			1,129
Deficiency since first of year (Per cent)			8.8

Table 3 shows that at Washington the total solar and sky radiation was below the normal during the first and third decades of February. The deficiency for the month is 9.6 per cent of the average February total radiation, and the deficiency since the first of the year is 8.8 per cent of the average amount of radiation received in January and February.

At Washington, therefore, while there was more than the average amount of cloudiness during February, when the sky was clear the solar radiation was of average intensity. At Madison, Lincoln, and Santa Fe it was above its average intensity.

METEOR OBSERVATIONS.

The report of the committee on meteors of the American Astronomical Society, recently published with other reports by the society, points out the importance of the study of meteors and its profound relation to the earth's atmosphere, its gases, and the absorption phenomena that take place in its upper strata. Further great advantages must result from the application of more accurate methods of observation and photographic record. The chairman, Prof. Cleveland Abbe, states that suggestions for the construction of a photographic meteor-graph as devised by himself, have been submitted to the Research Laboratory of the Eastman Kodak Co., Rochester, N. Y.; as also suggestions for a less desirable but simpler form for the general use of those interested in the subject. Having no funds at his disposal, he has urged the Kodak Co. to construct a few copies and put them on the market, so that the world may realize the importance of the work. The report concludes as follows:

"It is not likely that I shall be able to contribute much more to this study, but I hope the Astronomical Society will stimulate some abler member to devote himself to this important branch of Astro-meteorological and physical study."

AREQUIPA PYRHELIOMETRY.[1]

(Summarized for the REVIEW.)

This paper is a summary of observations taken at the station of the Harvard College Observatory at Arequipa, Peru ($\phi = 16° 22' 28.0''$ S.; $\lambda = 4^h 46^m 11.73^s$ W.; alt. 2,451 m.) by its observers, with a Smithsonian silver-disk pyrheliometer lent for the purpose by the Smithsonian Institution. The observations have been reduced at the Astrophysical Observatory of the Smithsonian Institution under the direction of its director, C. G. Abbot. Humidity determinations were made sometimes by means of whirled wet- and dry-bulb thermometers, sometimes by the recording hair-hygrometer.

Monthly mean values are given in the author's Table 2, which is here reprinted, for the following elements:

$e_{1.2}$, intensity of solar radiation at air mass 1.2 (sun's zenith distance, z, 24°, sec. $z = 1.2$).

a_2, the transmission coefficient, computed from measurements of radiation intensity with sun at $z = 60°$ and $z = 0°$.

p, pressure of aqueous vapor.

e_0, empirical solar constant, computed by formulæ I and II given below.

n, number of days on which radiation was observed. The means inclosed by parentheses are based on very meager data.

[1] *Abbot, C. G.* Arequipa pyrheliometry. Washington, 1916. 23p. 2 figs. 8°. (Smithsonian misc. coll., v. 65, no. 9. Publ. 2367.)

TABLE 2.—*Monthly mean values for Arequipa, Peru.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1912.												
Radiation, $\epsilon_{1.2}$								1.487	1.487	1.558	1.547	1.520
Transmission, a_2								0.847	(0.821)	0.869	.....	(0.848)
Vapor pressure, p								.....	.....	.....	3.00	7.28
*Solar constant, ϵ_0 I.								(1.93)	(1.91)	(1.98)	(1.97)	1.94
*Solar constant, ϵ_0 II.								.....	.....	.....	.....	1.97
Number days, n								13	25	21	7	8
1913.												
Radiation, $\epsilon_{1.2}$	1.469	(1.464)	(1.321)	1.412	1.478	1.501	1.470	1.457	1.478	1.425	1.503	1.518
Transmission, a_2	(0.821)	.....	(0.845)	0.851	0.878	0.879	0.875	0.856	0.848	0.826	(0.843)	0.831
Vapor pressure, p	8.95	(9.65)	(8.00)	6.89	4.29	3.71	3.07	4.56	4.87	6.00	6.70	7.24
*Solar constant, ϵ_0 I.	1.91	.....	.....	1.86	1.92	1.94	1.87	1.88	1.90	1.86	1.92	1.93
*Solar constant, ϵ_0 II.	1.91	.....	.....	1.89	1.92	1.93	1.89	1.89	1.92	1.89	1.95	1.95
Number days, n	5	1	1	6	12	15	17	19	18	13	12	15
1914.												
Radiation, $\epsilon_{1.2}$	1.495	1.463	1.470	1.485	1.451	1.496	1.514	1.516	1.521	1.542	1.529	1.544
Transmission, a_2	0.838	(0.861)	0.886	0.886	(0.882)	0.902	0.855	0.889	0.862	0.842	0.843	.....
Vapor pressure, p	7.35	9.61	8.85	6.49	7.00	4.50	3.83	4.16	4.65	4.58	4.83	5.89
*Solar constant, ϵ_0 I.	1.91	1.91	1.93	1.95	1.94	1.96	1.95	1.96	1.94	1.95	1.92	1.94
*Solar constant, ϵ_0 II.	1.92	1.92	1.91	1.92	(1.90)	1.91	1.98	1.94	1.94	1.96	1.91	1.93
Number days, n	11	11	15	14	6	11	22	18	13	19	7	8
1915.												
Radiation, $\epsilon_{1.2}$	1.523	1.478	1.493	.....	.....	.....	.....	.....	.....	.....	.....	.....
Transmission, a_2	.....	(0.917)	0.881	.....	.....	.....	.....	.....	.....	.....	.....	.....
Vapor pressure, p	5.19	8.50	7.93	.....	.....	.....	.....	.....	.....	.....	.....	.....
*Solar constant, ϵ_0 I.	(1.90)	(1.92)	1.97	.....	.....	.....	.....	.....	.....	.....	.....	.....
*Solar constant, ϵ_0 II.	.....	(1.85)	1.96	.....	.....	.....	.....	.....	.....	.....	.....	.....
Number days, n	3	4	7	.....	.....	.....	.....	.....	.....	.....	.....	.....
Weighted mean, $\epsilon_{1.2}$	1.493	1.467	1.475	1.463	1.469	1.499	1.495	1.486	1.492	1.512	1.522	1.526
Values, a_2	0.832	(0.880)	0.878	0.870	0.880	0.885	0.865	0.865	0.850	0.845	0.843	0.835
All years, p	7.42	9.58	8.28	6.60	5.20	4.05	3.48	4.36	4.77	5.15	6.00	6.80
Total days, n	19	16	23	20	18	26	39	50	56	53	26	28
Weighted mean value for mean solar distance, $\epsilon_{1.2}$	1.448	1.434	1.462	1.474	1.502	1.547	1.543	1.521	1.511	1.500	1.488	1.480

* Computed by formulæ I and II as given below.

From the study of this table Mr. Abbot concludes that there is no indication that the years August, 1912, to March, 1915, inclusive, were other than normal years for Arequipa (unless as to the number of clear days, which is not discussed); a particularly interesting conclusion since the Mount Katmai eruption in June, 1912, inaugurated great decreases in direct solar radiation received at the earth's surface over the Northern Hemisphere, whose effects could still be there traced near the end of 1913. "The volcanic dust from Katmai, though general in the Northern Hemisphere, seems not to have crossed the equator."

The close connection at Arequipa between solar radiation at the earth's surface and atmospheric humidity, is brought out by a remarkably smooth curve defined by $e_{1.2}$ (reduced to mean solar distance) and p. Apparently the degree of atmospheric humidity at the earth's surface is a good index of the total quantity of humidity existing between this high-level station and the limit of the atmosphere. He says:

> It is obvious, of course, that fluctuations of atmospheric transmission coefficients must also produce their effect on the observed intensity of observed solar radiation at the station. Such fluctuations are of two kinds: (1) Those associated with changes of water vapor; (2) those associated with changes of dustiness, such as those produced in the Northern Hemisphere by the Katmai eruption. The influence on the solar radiation of fluctuations of the first type, which are a function of the humidity, may be generally (for a high-level station like Arequipa) much greater than those associated with dust alone. But it might well be expected that for certain months of the year the dust fluctuations would be by no means negligible. However, restricting our thought to a high-level station like Arequipa, and remembering the powerful true absorption produced in the infra-red spectrum by water vapor and the large changes in this true absorption attending changes in humidity when the humidity and the air mass are both small, it is easy to see after all why the observed radiation at $M=1.2$ at Arequipa seems to be so well represented as a function of water vapor alone. For both the true absorption and a large proportion of the variable elements of the general scattering are functions of water vapor. Compared to these, the variable scattering produced by dry dust alone is generally small.

The relation between these factors at Arequipa are then brought out in two laws, one of which (I) expresses the radiation $e_{1.2}$ (reduced to mean solar distance) as a function of the vapor pressure, p, only, the other (II) as a function of vapor pressure, p, and the transmission a_2.

I. $e_{1.2}^{corr.}$ ($e_{1.2}$ reduced to mean solar distance)

$$=0.981+\frac{0.75}{p^{0.222}}, \qquad (1)$$

II. $e_{1.2}^{corr.}=1.50+(5.25-p)0.19+(a_2-0.85)0.63.$ (2)

Dividing I and II by 1.93, the mean of his previous determinations for the solar constant, he derives two other laws for computing the solar constant ϵ_0, as follows:

$$\text{I. } \epsilon_0=\frac{e_{1.2}^{corr.}}{0.508+\frac{0.389}{p^{0.222}}}, \qquad (3)$$

$$\text{II. } \epsilon_0=\frac{e_{1.2}^{corr.}}{0.777+(5.25-p)0.01+(a_2-0.85)0.33}. \qquad (4)$$

The monthly mean values of ϵ_0 at Arequipa computed from formulæ I and II for ϵ_0, together with the monthly means of spectrobolometric determinations made at Mount Wilson, Cal., for the years 1913 and 1914 are given below in the author's Table 3.

TABLE 3.—*Mean monthly solar constant values.*

Month.	1913					1914				
	July.	Aug.	Sept.	Oct.	Nov.	June.	July.	Aug.	Sept.	Oct.
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Arequipa, I	1.87	1.89	1.90	1.86	1.92	1.96	1.95	1.96	1.94	.....
Arequipa, II	1.89	1.89	1.92	1.89	.....	1.91	1.98	1.94	1.94	.....
Number of days	17	18	18	11	12	11	22	18	13	.....
Mount Wilson	1.925	1.931	1.920	1.874	1.876	1.952	1.956	1.964	1.943	.....
Number of days	3	18	25	24	5	14	14	22	18	.....

Disregarding the months of lesser weight, indicated by the small number of days, it appears that these two widely separated stations agree in showing that the solar constant was decidedly higher in 1914 than in 1913.

Finally, the 29 days with solar-constant values available for favorable comparison between Arequipa and Mount Wilson have been grouped into high values and low values, as indicated by Mount Wilson work and the resulting mean solar constants (with their differences) are shown in Table 4.

TABLE 4.

Station.	Group A.	Number days.	Group B.	Number days.	A-B.
	Gr.-cal.		*Gr.-cal.*		*Gr.-cal.*
Mount Wilson	1.954	15	1.893	14	0.061
Arequipa, formula (3)	1.936	15	1.900	14	.036
Arequipa, formula (4)	1.943	13	1.907	14	.036

This tends to confirm the previously discovered short-period irregular solar variations.

The author sums up his results as follows:

Observations with the silver-disk pyrheliometer and nearly simultaneous measurements of atmospheric humidity have been made since August, 1912, at Arequipa, Peru, at the station of the Harvard College Observatory.

From these observations have been determined values of the solar radiation at Arequipa corresponding to sec. z=1.0, 1.2, and 2.0; values of pressure of aqueous vapor, and values of the diminution of radiation attending the passage of the sun from the zenith distance whose secant is 1.0 to that whose secant is 2.0.

Owing to other occupations the observers have generally made these observations when the sun was within 60° of the zenith. On this account determinations of atmospheric transparency are not always possible, and are of less weight than other data given.

The results are collected to give monthly mean values. These show a remarkably close connection between radiation and vapor pressure. Advantage is taken of this close correlation to determine by empirical formulæ values of the solar constant of radiation. These empirical values agree quite as well as could be expected with values obtained at Mount Wilson, Cal., by complete spectrobolometric and pyrheliometric measurements combined. The Arequipa results confirm the variability of the sun, both from year to year and from day to day, shown by investigations at Mount Wilson and elsewhere.

It seems probable that from observations similar to those at Arequipa, if conducted at 8 or 10 favorable stations of high level in various parts of the world, the variations of the sun could be determined almost or quite as certainly as from two stations equipped for complete spectrobolometric determinations of the solar constant.

The Arequipa results indicate that the volcanic dust which was general in the atmosphere in the Northern Hemisphere for more than a year after the volcanic eruption of Mount Katmai, Alaska, in June, 1912, did not influence the transparency of the atmosphere in Peru.

HORIZONTAL RAINBOWS ON LAKE MENDOTA.

By CHANCEY JUDAY.

[Laboratory of the Wisconsin Geological and Natural History Survey, Madison, Wis. Feb. 26, 1916.]

During the past decade horizontal rainbows or color spectra have been observed a number of times on the surface of Lake Mendota at Madison, Wis. These spectral phenomena have not appeared every year during this period of time, but they have been noted during at least 5 of the past 10 years and on more than one date in each of the 5 years. With one exception, namely, May 24, 1915, they have been confined to the autumn of the year. They have varied in extent from mere bright spots, in which the spectral colors were scarcely discernible, to brilliant bows which have attracted considerable attention.

Previous observations.

Such phenomena have been observed on various bodies of water in Europe, and the fact that they appear most frequently in autumn has led the Swiss and German writers to designate them as "Herbstiris." Apparently the first record of such a phenomenon is that cited by Forel,[1] who states that Wartmann observed two displays of iris on the surface of Lake Geneva, Switzerland. One was noted on November 2, 1868, and the other on February 11, 1872. Similar phenomena were noted on Lake Geneva by two other observers, one on July 5, 1871, and the other on December 28, 1876. Wartmann attributed the spectra which he saw to the existence at the surface of the water of a considerable quantity of powdery material. These small particles produced a series of depressions in the surface film which acted like a prism in dispersing the rays of light. Forel himself expresses the opinion that these spectra were produced by thin layers of oil on the surface of the water.

J. C. Maxwell [2] described a horizontal rainbow that was seen at about noon on January 26, 1870, on the frozen surface of the ditch surrounding St. John's College at Cambridge, England. He attributed the spectral display to drops of water on the surface of the ice. The angle between the bright red of the bow and the sun's ray was 41° 50′ while that of the blue was 40° 30′.

Hewitt [3] states that a horizontal rainbow was seen on Lake Windermere, England, by Kay in November, 1885. On November 6, 1903, Hewitt observed two spectra, one of which was fainter than the other, on one of the ponds in Vernon Park at Stockport, England. These rainbow colors were visible for more than four hours and were produced by droplets of water which a fog deposited upon a film of carbonaceous dust resting upon the surface of the pond.

Hann [4] observed a rainbow on Lake Constance on September 25, 1903, during a foggy morning. In describing the phenomenon he states that "es waren die Fusspunkte eines Regenbogens, der aber nur in dem Nebeldunste über dem See seinen Ursprung haben konnte."

On April 11, 1906, Church [5] saw a horizontal bow on Loch Lomond, Scotland. It was a perfectly still, cloudless day, and the phenomenon was attributed to a film of fog left undisturbed on the calm surface of the water.

Schaffers [6] has described a horizontal rainbow which he saw on a small pond in the vicinity of Louvain, Belgium. He attributed it to droplets of water about a tenth of a millimeter in diameter which rested upon a scum composed of minute animals and plants. This bow had the form of an arc of an ellipse. The angular distance of the primary bow was 40° to 42° and, rarely, a secondary bow appeared at an angle of 53°.

Schroeter [7] has described a rainbow which he saw on the surface of Lake Zurich. According to him it was produced by droplets of water deposited by mist or fog upon an oily scum that covered the surface of the lake. Wyss [8] has also observed this phenomenon on Lake Zurich a number of times, and he has attributed it to the presence at the surface of the lake of very large numbers of the small crustacean *Daphnia longispina*. These daphnids come to the surface in great numbers in the

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[1] Le Lémant. II, p. 505, 1895.
[2] Proc. Roy. Soc. Edinb., 1869–72, **7**:69; Sci. papers, v. 2, p. 160.
[3] Nature (London), 1903, **69**:57.
[4] Meteorolog. Ztschr., Wien, 1903, **20**:520.
[5] Nature (London), 1906, **73**:608.
[6] Nature (London), 1906, **74**:125.
[7] Internat. Rev. d. ges. Hydrob. & Hydrog., 1908, **1**:747.
[8] Revue Suisse de Zoöl., 1909, **17**:441.

autumn, and the ephippia which they bear possess cross-hatch markings which, according to Wyss, act as diffraction gratings in separating the sunlight into its primary colors.

Wesenberg-Lund [9] records having seen such a display on a pond after it was covered with ice. He states that it was produced by droplets of water resting on an oily scum covering the surface of the ice.

Japanese [10] observers have seen these horizontal spectra on the moat surrounding the Central Meteorological Observatory and on Sinobazu pond at Tokyo and on the surface of Lake Suwa. One of them, Fujiwhara, has attributed this phenomenon to droplets of water floating in the air over the surface of the lake or pond but not resting upon the surface of the water or the ice.

Observations on Lake Mendota.

With respect to their origin, it may be said that the horizontal bows observed on Lake Mendota were produced by small drops of water resting upon a scum which covered the surface of the lake, thus preventing the coalescence of the drops with the water beneath. When the sunlight strikes these droplets, the beams of light are reflected and refracted just as they are in the raindrops which produce the regular rainbow. Measurements show that the angular distances in the horizontal bow are substantially the same as those of the regular rainbow, thus indicating that the horizontal bows are produced by drops of water and not by something which serves as a diffraction grating. The droplets borne by the scum may also be readily recognized with a hand lens.

The type of horizontal bow most frequently seen on Lake Mendota consists of one or two more or less brilliant spots of light in which the spectral colors are readily distinguishable. These spots represent the segments of the bow. If conditions are more favorable, the bow is complete but parabolic in form instead of semicircular, as in the regular rainbow, with the observer at the apex of the parabola. (See fig. 1.) The outer extremities of the bow constitute the widest and most brilliant parts, and from them two narrow, bright bands of light approach the observer. Usually the spectral colors are scarcely recognizable in these bands, but sometimes yellow and red are readily discernible. Sometimes the primary bow is double, the inner bow only rarely being complete. The secondary bow appears at some distance outside the primary bow, with the colors in the reverse order, just as in the regular secondary rainbow. Usually it is nothing more than a bright spot of light, but sometimes it is brilliant enough to show the spectral colors distinctly. No band between the observer and the bright spot of the secondary bow has ever been noted.

In general these horizontal rainbows are confined to the early hours of the day but in a very few instances they have been visible as late as 2 p. m. They have been seen when the observer was 10 to 12 meters above the surface of the lake, but no greater height than this has been tested so that the maximum altitude at which they are visible is not known. They have also been seen when the observer's eyes were within half a meter of the surface of the water; sometimes, in fact, they are brighter when the eyes are near the surface.

During the month of October, 1914, horizontal bows were observed on Lake Mendota several times, and on two dates, namely, October 6 and 23, the displays were unusually brilliant and complete. Observations were made near the middle of the lake on these days and they were made from a launch so that the eyes of the observer were approximately a meter and three-quarters above the surface of the water. As shown in the diagram (fig. 1), these horizontal bows consisted of three primary ones, Nos. 1 to 3 in figure 1, in which the colors were arranged as in the primary rainbow, that is, with the red on the outside and the violet on the inside. A secondary bow, No. 4 in figure 1, appeared at some distance outside the primaries and in it the colors were reversed.

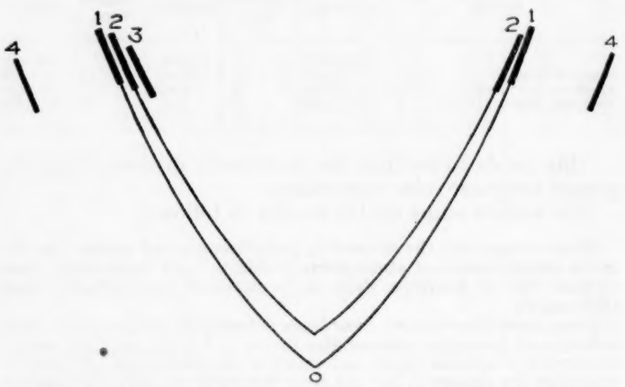

FIGURE 1.—Diagram of horizontal rainbow observed on Lake Mendota, Wis., October 23, 1914.
1, 2, 3, indicate the three primary bows.
4, the secondary bow.
O, the observer at the apex of bow 1.
The heavy lines at the outer ends of the bows indicate the widest portions in which the spectral colors, red outside and violet inside, were distinct. These bright portions were in immediate mutual contact, but have been separated in the diagram for the sake of clearness. They are represented as about 250 meters from O.

The outside member of the primary series, No. 1, was the main bow and was complete on both dates. That is, from the bright portion at the extremities where the spectral colors were very distinct (indicated by a wider line in the diagram) a bright band extended to the observer on either side as shown in figure 1. Just inside this was bow No. 2 which was complete on October 23 as shown in the diagram, but which lacked the bright bands approaching the observer on October 6. The red at the extremities of bow No. 2 was in immediate contact with the violet of bow No. 1, but they have been separated in the diagram in order to show the two more distinctly. The bright bands approaching the observer were distinctly separated from those of No. 1 and they met about 20 meters in front of the observer. Bow No. 3 was distinctly seen on both of the above dates but it was limited to the left segment, no trace of it being visible on the right side. It did not contain all of the primary colors, only red, orange and yellow being visible. Neither did it possess a band approaching the observer. In this instance also, the red of No. 3 was in immediate contact with the violet of No. 2, so that the three primary bows constituted a continuous series at their extremities.

The distance of the chief, or the brightest, portions of these bows from the observer seemed to show considerable variation. At times that of No. 1 did not appear to be more than 200 meters away, then again it would seem to be fully five or six times as far. The bright portion of bow No. 3 came about 30 to 50 meters nearer the observer than No. 1, while No. 2 was intermediate. The width of the bright extremity of bow No. 1 showed some

[9] Internat. Rev. d. ges. Hydrob. & Hydrog., biol. Sup., Erste Serie, 1910, p. 43.
[10] MONTHLY WEATHER REVIEW, 1914, 42:426.

variation, but in general it was estimated at 10 to 12 meters. Bow No. 2 was only one-half to two-thirds as wide and bow No. 3 only about one-third as wide as No. 1. The secondary bow, No. 4, had about the same width as No. 1.

In bow No. 1 the beams of sunlight entered the droplets of water directly and underwent reflection and refraction as in the regular rainbow, but the manner in which bows No. 2 and No. 3 were produced is not so clear. A difference in the size of the drops affects the angular distance of the bow, but it scarcely seems credible that this factor was responsible for these supernumerary bows. It seems more probable that the beams of light which produced them, first impinged upon the surface of the lake and were then reflected into the droplets.

The horizontal rainbow which was seen on May 24, 1915, possessed some features which deserve attention. As already stated it is the only one that has been observed in any other season of the year than autumn. It was visible from 6:45 a. m. to 8:30 a. m., and consisted of a single series of spectral colors. The right segment only was noted and it was complete during a considerable portion of this time. During the remainder of the time only the bright distal portion of the segment was visible.

The bright portion at the outer extremity of the bow increased in width as the sun rose higher above the horizon. At 7:20 a. m. it did not appear to be more than 5 meters wide; at 7:45 it was at least 10 meters wide, and by 8:10 a. m. its width was estimated at 30 meters; a launch resting in the rainbow and at right angles to it served as a good unit of measurement in making the last estimate. Blue and violet constituted nearly half of the bow when it reached its maximum width.

Also as the sun rose higher, the bright portion of this horizontal rainbow approached the observer, and just before its disappearance, about 8:30 a. m., the intervening distance was only 115 meters.

In conclusion it may be said that the conditions which appear to be necessary for the production of this phenomenon on Lake Mendota are as follows: (*a*) A scum or film on the surface of the water which may consist of an oily soot or of plankton organisms, generally algæ; (*b*) a fog which deposits minute drops of water on this scum; (*c*) a perfect calm which facilitates the formation of the scum and also permits the globules of moisture to remain as individual droplets; (*d*) a bright sun.

HALOS AT FORT WORTH, TEX., AND THEIR RELATION TO THE SUBSEQUENT OCCURRENCE OF PRECIPITATION.

By HOWARD H MARTIN, Assistant Observer.

[Dated, Weather Bureau, Fort Worth, Tex., Feb. 23, 1916.]

The halos recorded in the following tables were observed at Fort Worth, Tex. (lat. 32° 43′ N.; long. 97° 15′ W.). The record of halos has constituted a portion of the daily routine of a regular Weather Bureau station, established September 1, 1898. However, early unfamiliarity with the practical methods of halo observation brought about the record of many halos prior to 1910 with insufficient details as to attending phenomena. In practically all cases the actual hour of occurrence, the duration and the angular measurements were omitted. For this reason, and that these results may be compared with those obtained at York, N. Y., only those halos noted between January 1, 1910, and December 31, 1915, are used. It is believed that since January 1, 1910, not more than 5 per cent of all solar halo phenomena have escaped record.

TABLE 1.—*The number of solar and lunar halos observed at Fort Worth, Tex., Jan. 1, 1910, to Dec. 31, 1915, inclusive.*

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1910	7	1	2	5	5	2	0	3	0	1	5	3	34
1911	4	2	5	3	4	2	2	0	0	3	2		27
1912	6	3	3	5	5	3	2	0	0	4	1	1	33
1913	3	2	5	1	2	2	6	1	0	5	1	1	29
1914	2	3	0	1	1	4	5	0	0	4	2	1	23
1915	2	6	2	2	1	1	0	1	2	0	2	5	24
Total	24	17	17	17	18	14	15	5	2	14	14	13	*170
Means	4.0	3.0	3.0	3.0	3.0	2.3	2.5	0.9	0.3	2.3	2.3	2.1	28.2
Smoothed means [1]	3.3	3.2	3.0	3.0	2.8	2.5	2.0	1.2	1.0	1.7	2.2	2.5	28.2

* Of this total, two are discarded in other results because of incomplete data.

[1] E. g., January $= \frac{\text{Dec.} + 2\,\text{Jan.} + \text{Feb.}}{4}$

Table 1 includes both solar and lunar halos noted during this period, showing their relative monthly frequency without regard to the time of occurrence. It will be readily seen that this section of the country observes far fewer halos than either Blue Hill Observatory, Mass., or York, N. Y. The possible reason for this may be the fact that as Fort Worth is far south of the usual cyclone "lanes," it is favored with the cirro-stratus advance guard from only those lows of the Alberta type that recurve far enough south to affect the weather at this station at all, and from the relatively infrequent southern Pacific type, moving eastward from the arid regions.

Table 2 shows the frequency with which these halos were followed by precipitation, and the average length of time before such precipitation occurred. The results show even less uniformity, with regard to the seasonal effects than do either the York, N. Y., observations or those obtained at Blue Hill. The normal length of time elapsing before precipitation (24.1 hours) is much in excess of that at York, N. Y. (20.5 hours), and of that at Blue Hill (15.6 hours). Halos at Fort Worth are by far most frequent in January, and least frequent in September. In fact, during the entire record of 18 years, but two halos, one solar and one lunar, have been recorded in the latter month.

TABLE 2.—*Relations of occurrence of halos to the occurrence of precipitation at Fort Worth, Tex., from Jan. 1, 1910, to Dec. 31, 1915, inclusive.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Total number considered	23	17	17	17	18	14	15	5	2	14	13	13	168
Per cent followed by rainfall within 18 hours	17	36	28	23	28	20	23	20	50	50	22	23	26
Per cent followed by rainfall within 24 hours	22	53	33	30	40	27	30	40	50	60	36	46	36
Per cent followed by rainfall within 36 hours	39	70	44	30	61	33	30	40	50	70	66	56	48
Per cent followed by rainfall within 48 hours	55	88	50	70	72	33	48	60	50	70	66	56	59
Per cent not followed by rain in 60 hours	33	12	50	30	28	64	48	20	50	20	34	44	32
Average duration	1.8	1.7	1.8	1.9	2.0	1.9	1.8	1.7	1.8	1.8	1.9	2.0	1.8
Average hour of occurrence (first seen)	15.2	17.3	14.8	14.6	15.5	12.5	13.6	11.0	17.0	12.6	12.7	13.8	14.2
Average number of hours between halo and precipitation	25.5	23.2	22.4	28.7	22.2	25.1	26.8	31.8	27.0	17.3	21.4	17.7	24.1

The wind direction during and immediately following the observation of a halo seems to play an important part in its verification as a rain prognostic. Of the 168 halos recorded, 94 were attended or followed by easterly winds and falling pressure. Of these, 82, or 87 per cent, were followed by precipitation within 48 hours. This result is important, in view of the fact that of the total number of halos recorded, but 99, or 59 per cent, were followed by rain or snow within 48 hours.

Unusual displays, Fort Worth, Tex.—Complex halos are rare indeed. Even the 46°-halo occurs but infrequently. From the time angular measurements were first made at this station, seven 46°-halos have been recorded. On the evening of May 23, 1901, two parhelia were noted as the sun was about 10° above the western horizon. They appeared on the edge of a bank of alto-stratus clouds. Between this edge and the horizon the sky was clear, while above the clouds were so dense as to obscure all evidences of the parhelic circle [?]. The parhelia were about 23° distant from the sun.

At about 6 p. m. on July 2, 1914, a complex halo with three parhelia was observed. The two brightest parhelia were vertically above and below the sun, while the parhelion to the south or left of the sun was but little more than an irregular splotch of light. The phenomenon lasted about 45 minutes, and occurred during a general rain over western Texas; for this reason it is supposed that this station was in the outskirts of the alto-stratus cloud region. No color was observed in the phenomenon, and no rain followed at Fort Worth within several days.

Many of the 22°-halos occur with a cirro-stratus overflow which precedes the incoming high. These halos are almost invariably followed by northerly winds and rarely by precipitation. Local thunderstorms are frequently preceded by halos, usually solar and occurring during the morning hours. These halos are followed by the usual meteorological conditions preceding a thundershower. It is also observed that halos occurring with brisk south winds and falling pressure will not be followed by rain if the wind shows a tendency to increase in velocity and shift to the southwest, but that halos followed by southwest winds and rising pressure will almost invariably be followed by rain within 24 hours.

Halos are not infallible weather signs, but when properly considered in conjunction with other features they serve as a material aid to the forecaster.

ORIGIN AND MAINTENANCE OF THE EARTH'S ELECTRIC CHARGE.[1]

By W. F. G. SWANN.

(Read at the special meeting on atmospheric physics of Section B, American Association for the Advancement of Science, San Francisco, Aug. 5, 1915.)

[Author's abstract.]

The paper consists of two parts. Part I is devoted to a general discussion of certain broad principles which must be considered in the formation of any theory of atmospheric-electric phenomena, and to a consideration of former theories. In Part II a new hypothesis is provisionally formulated, and its consequences are traced.

Part I commences by considering the possibility of a general circulation in the atmosphere by which the negative electricity flowing upward at one place is conducted down at some other place. It appears that such an explanation is untenable, for no regions have been discovered presenting the phenomenon of a continual return current, and apart from this fact, the existence of a circulation of the kind depicted would necessitate that the electromotive forces around closed paths, in which the flow was taking place, would have to be of the order of magnitude of 10^5 volts. *Electrostatic* forces can contribute nothing whatever to a line integral around a closed circuit. A consideration of such values of the line integral as could be obtained on the basis of the change of magnetic induction due to the earth's magnetic field through a closed circuit, or of the motion of the earth and atmosphere in the magnetic lines of force of the earth shows that, apart from the circumstance that they would be of a nature unsuitable to correspond to the facts, they would be of an order of magnitude entirely too small to play any appreciable part in the phenomena.

The various possible types of hypotheses which may be made to account for the maintenance of the earth's charge are capable of being grouped under three heads: (1) We may imagine that negative electricity is fed into the earth from the outside in some unspecified manner. In this case it will be necessary to assume that the vertical conduction current is dissipated again into space. (2) We may imagine that negative electricity is supplied continuously to the earth and positive electricity to the atmosphere at all places. (3) We may imagine that negative electricity is supplied continuously to the earth and positive electricity to the atmosphere, the supp taking place, however, over only a limited region at any one time.

Considering the hypotheses of the first type, it turns out that in view of the fact that the earth is a comparatively good conductor of electricity, the charge will distribute itself uniformly over the earth's surface. The known fact that the conductivity continually increases with altitude to a high value is all that is necessary to insure that things will arrange themselves so that the positive charge in the atmosphere is equal to the negative charge on the earth.

Considering the hypothesis of type 3, it turns out that in regions where the replenishment of charge to the earth and atmosphere is not taking place, the potential-gradient and earth-air current-density would, under ordinary conditions, quickly fall to an insignificant value. If, however, a very high value is assumed for the conductivity of the upper atmosphere, this difficulty to some extent vanishes, and the assumption of a replenishment of the charge at one place is sufficient to account for the maintenance of atmospheric-electric phenomena at all places.

A discussion of several former theories is given; among others, those of Elster and Geitel and of Ebert. In these theories a separation of positive and negative electricity takes place in such a way that negative electricity is left on the earth and positive is supplied to the atmosphere. The positive charge is carried upward by the ascending air currents, and in the steady state; the convection current so produced must be equal and opposite to the conduction current. Apart from the objections which have been raised by others against the Elster and Geitel theory, it is shown that, owing to the conductivity of the atmosphere, the rising positive electricity would become devoured, as it were, before it had reached any great altitudes, and the net result is that on such a theory the potential-gradient and earth-air current-density would be expected to diminish to practically a zero value at altitudes of the order of magnitude of 1,000 meters, which is contrary to the results of balloon experiments. The objection here cited applies to any form of theory in

[1] Reprinted from Carnegie Institution of Washington, Yearbook No. 14, for the year 1915, pp. 339–341. (Text of the paper appears in full in "Terrestrial Magnetism," September, 1915, 20:105–126.)

which the convection current is supposed to balance the conduction current.

The hypothesis provisionally formulated in Part II consists in assuming that each cubic centimeter of the atmosphere emits negative corpuscles of a penetrating power sufficiently great to enable them to travel through considerable thicknesses of the atmosphere. The earth will absorb the corpuscles which fall upon it, and its potential will rise, in a negative sense, until the negative conduction-current back to the various parts of the atmosphere balances the charging effect due to the expulsion of the corpuscles. The total positive charge in the atmosphere will of necessity be equal to the negative charge on the surface of the earth. In the steady state the resultant downward corpuscular current at any altitude will just balance the upward conduction current at that altitude. A general consideration of the order of magnitude of the phenomena concerned shows that it is only necessary to assume an extremely small rate of emission of corpuscles per cubic centimeter, and though the degree of penetration necessary for these corpuscles is greater than any we are familiar with in laboratory experiments, a full consideration of all the circumstances shows that the assumption is not as unreasonable as might at first sight be supposed.

In the simplest case, where the rate of emission of corpuscles and the average range of a corpuscle are independent of the altitude, the corpuscular current-density and consequently the conduction current-density should decrease to practically a zero value at an altitude comparable with the average range of a corpuscle. In the more general case where the rate of corpuscular emission and the range of the corpuscles increases with the altitude, the variation of the conduction current-density with altitude becomes more complex, and it becomes possible in a natural way to explain on these lines the general features of the variations of the conduction current with altitude in so far as this variation is known. The argument in this connection is too involved to be made clear in an abstract, and a similar remark applies to a consideration of the question of annual and diurnal variation; it may be remarked, however, that the more prominent features of these variations fall into natural line with the conclusions resulting from the development of the hypothesis.

In conclusion, it is to be remarked that there is considerable latitude in the exact nature of the hypothesis which may be formulated in order to account for the general features of atmospheric-electric phenomena along the above lines.

SECTION II.—GENERAL METEOROLOGY.

METEOROLOGY OF THE MOON.[1]

By Prof. WILLIAM H. PICKERING.

[Dated: Harvard Astronomical Station, Mandeville, Jamaica, February 4, 1916.]

In the days of Sir William Herschel it was believed that the moon was a living planet, with active volcanoes, and even possibly intelligent life upon its surface. In the nineteenth century astronomers changed their views, and following them the public. The change was gradual, but toward the end of the century many went so far even as to say that no alterations of surface of any kind had ever been detected upon the moon and that it was a dead, changeless, and burned-out cinder. And this was said and written in spite of the expressed opinion of all of the world's greatest selenographers to the contrary—Schroeter, Maedler, Schmidt, Webb, Neison, Birt, Elger, Klein, and others. That is, the opinions of those who had made a life-study of the moon were all disregarded as of no value, in favor of the views of some modern popular astronomers who had never given even a single month's study to our satellite.

Of late years, however, more attention has been paid to the moon. Instead of its being totally neglected by astronomers, powerful telescopes situated in favorable climates have been turned on it, with the result that the pendulum has already begun to swing the other way. Thus M. Jassy Desloges,[2] using a 20-inch telescope located in Algeria, has confirmed certain changes noted by the writer in the craters Linné, Plato, and Messier, has detected certain others which have since arisen, and has made other observations showing changes in Dawes and Alpetragius. The director of the lunar section of the British Astronomical Association,[3] in a recent paper, says: "It is now well established that periodic changes do occur in each lunation in connection with many objects on the moon's surface."

In a discussion of lunar changes, and particularly of lunar meteorology, it is necessary first to state a few astronomical facts, and explain a few astronomical terms. Thus the earth and the moon both revolve about the sun in nearly the same orbit, but are continually crossing one another's paths, and mutually disturbing one another as they go, both orbits being always concave toward the sun. The diameters are not unlike, being in the ratio of 3.7 to 1. The earth-moon system is therefore, strictly speaking, simply a double planet. It is not at all similar to the case of the other satellite systems, where each satellite revolves primarily about a comparatively very large planet, and only secondarily and in consequence follows that body about the sun. In one respect our twin world differs very markedly from the earth—its equator is nearly parallel to its solar orbit. The inclination is only 1.5° in place of 23.5° as with us, and consequently there are no marked polar caps and no seasons in the sense that we find them on the earth. On the other hand the lunar day with regard to the sun is 29.5 of our days in length, instead of 24 hours.

For practical purposes, however, there are seasons, much as we have them at the terrestrial poles, and we may consider that for each lunar crater spring begins at lunar sunrise upon it, and lasts nearly 7.5 days, till the sun crosses its meridian which is its summer solstice. When the sun sets upon it 7.5 days later, we have its autumnal equinox. The winter solstice occurs when the sun is on the opposite side of the moon, 14.75 days after its midsummer. At the same moment that it is spring for one crater it may be summer for another, autumn for a third, and winter for a fourth, depending on their longitudes. The main difference between the conditions on the moon and at our poles is that the 6 months of daylight on the earth is reduced to 15 days upon the moon. The lunar days, however, are much hotter, and the lunar nights far colder than with us.

Astronomers measure the progress of the lunar day, which may thus also be considered to coincide with its year, in degrees of colongitude, as we measure the progress of the terrestrial day in hours of time. Colongitude 0° occurs when it is sunrise on the central meridian of the moon, that is in general at the first quarter. When it is colongitude 90° the moon is full, at colongitude 180° it is the third quarter, and at colongitude 270° it is new moon. We say "in general" because the phases of the moon depend upon the position of the earth, and occur therefore at somewhat irregular intervals, while the colongitudes depend on the position of the sun as seen from the moon, and are much more regular, corresponding to "Greenwich apparent time" on the earth.

Since longitudes on the moon are also counted from the central meridian, it follows that the common colongitude of the whole moon is always numerically equal to the longitude of those portions of its surface where the sun is rising, but this we need not stop to discuss further than to mention the fact.

Turning now for a moment to the planet Mars, which the moon resembles more closely than it does the earth, the fundamental fact on which is based the study of its meteorology is the melting of its polar caps. The moon has no well-defined polar caps, although its northern and southern limbs are appreciably brighter than either of its equatorial ones. There are, however, scattered over the whole of its surface, but in particular near its poles, numerous minute white spots more or less sharply defined and which we believe are due to snow or frost, and it is to some of these that we shall now direct our attention.

The object with which we will begin our studies is the well-known mountain Pico. This mountain is situated in longitude 9°, latitude +45°. Its vernal equinox therefore occurs at colongitude 9°, its summer solstice at colongitude 99° or just after full moon, and its autumnal equinox at 189°. Its altitude is 8000 feet or 2500 meters, and its length east and west 10″, 11 miles or 18 kilometers. No craters whatever have been detected upon it, but if any existed that were less than 0.1″ (500 feet or 150 meters) in diameter they would probably have escaped notice. It is not strictly a mountain in the geological sense of the word, but rather a spiracle or pinnacle, such as occur in some of our volcanic regions (Mem. Amer. Acad., **13**, Plates 19 and 20). Perhaps the best idea of

[1] Reprinted, with alterations by the author, from "Popular Astronomy," Williams Bay, Wis., March, 1915, v. **23**, No. 3. The illustrations, figures 1 to 8, inclusive, have been reengraved from the original drawings.—C. A. jr.

[2] Desloges, Jassy: Observations des surfaces planétaires, 2, 201, 215.

[3] Brit. astron. ass'n., 1915, **26**, 28.

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FIG. 1
Jan. 24, 1915
19°6, ×330, S. *9*

FIG. 2
Jan. 25, 1915
32°9, ×430, S. *12*

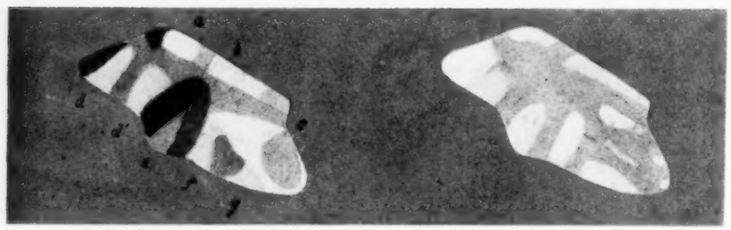

FIG. 3
Jan. 27, 1915
55°9, ×430, S. *10*

FIG. 4
Jan. 29, 1915
81°8, ×430, S. *11*

FIG. 9
Sept. 24, 1912
78°8, ×330, S. *10*

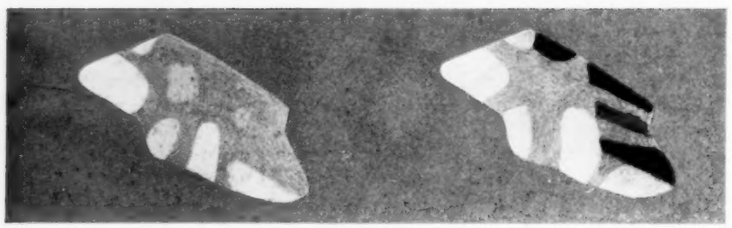

FIG. 5
Sept. 28, 1912
126°7, ×330, S. *10*

FIG. 6
Jan. 31, 1915
132°2, ×430, S. *10*

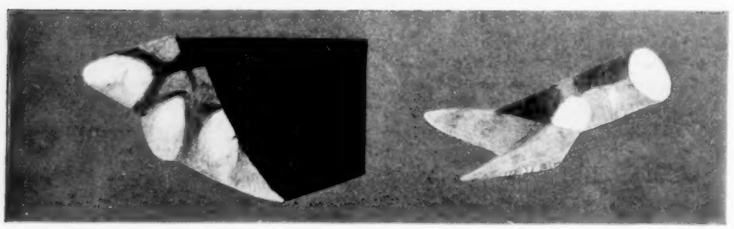

FIG. 7
Sept. 3, 1912
183°6, ×330, S. *12*

FIG. 8
Sept. 23, 1912
64°4, ×330, S. *8*

its appearance as compared with terrestrial mountains may be obtained from figure 7. The figures on this plate are all oriented with north at the top. This is unusual, but is better adapted to the illustration of the present paper than the usual orientation would be.

It is perhaps unnecessary to state that every line and shading shown in the drawing actually exists on the moon. It has not been touched up in any way to give it a resemblance to a terrestrial peak, but the mountain is represented exactly as it appears as seen through the telescope. Independent drawings made a little earlier and later in the lunation show practically every detail shown in the present sketch. It was drawn just as the sun was setting upon it, and consequently its western side is invisible. It must be remembered that on the moon the terms east and west are given the reverse meaning that they have on the earth and Mars. What we call east on the planets is called west on the moon, and vice versa.

Although this view gives the effect of having been sketched from but a slight elevation above the plain on which the mountain is situated, yet the angular elevation of the line of sight, as is shown by the latitude above given, is 45°. Pico is therefore not quite as steep as it appears in the sketch, the eastern slope lying at an angle of approximately 35°, and the western (shown in figure 1) of about 42°. It is also noticeable that the snow is found on the ridges, and not in the ravines, as in the case of our own large accumulations of ice. This is even more conspicuous in the case of Teneriffe shortly before the time of full moon, where the ridges and ravines are much more marked than they are on Pico.

As to the origin of the formation, it is pretty clearly a piece of the original lunar crust which was surrounded but not overwhelmed by the great fissure eruption causing the Mare Imbrium. The fact that the snow is found mainly upon the ridges leads us to believe that cracks exist along their crest lines. From these cracks water vapor escapes, and on account of the deficiency of the lunar atmosphere is immediately redeposited as snow. This peculiarity is shared by other lunar mountains as we have just seen.

In the accompanying plate the first seven drawings represent Pico. Under each is given the date, the colongitude, the magnification employed, and the quality of the seeing on a scale of 12. On this scale "12" is perfect for our 11-inch telescope, while "8" is better than we ever have in the north. Located upon the mountain are eight prominent white patches which we shall designate as snow. They have been lettered as indicated in figure 3. Although located in longitude 9°, yet so high does it rise above the surrounding plain, that the sun first touches its summit shortly before colongitude 7°. At 7.1° not only is spot *a* located upon the very summit of the mountain, dazzlingly brilliant; but the more elevated portions *b* and *c* can also be seen. By 9° *c* has rapidly increased in size, but *a* and *b* are practically unaltered.

At colongitude 19.6°, figure 1, *c* has about doubled its size, and other portions of the mountain are now visible, together with its long shadow, which is not shown in full on the plate, stretching away toward the east. Spot *a* is of brightness 10, and *b* and *c* 9, or a very little fainter.

By colongitude 32.9°, figure 2, nearly the whole of the southeastern side of the mountain has become visible, but none of the snow patches located upon it in some of the later figures have yet formed. Directly below the eastern summit, however, a crescent-shaped area has appeared which was described and painted as distinctly green, greener than the *mare*, which itself at this age of the moon is slightly greenish. Beneath the crescent a large area appears which is still in shadow, and close at hand to the west is another one, while spot *a* has increased in size, and the whole of it is now illuminated; spot *c* on the other hand has diminished, probably through melting. The next night at colongitude 44.0° much trouble was experienced from passing clouds, but it was clear that *a* was unchanged, while *c* had increased in size, appearing as in figure 1. This fluctuation in the size of *c* has been confirmed by later observations. The whole of the southeastern face was still dark. An observation made on September 21, 1912, at 40.7° records that there was no snow at all at that time on the eastern face of Pico.

In figure 3, colongitude 55.9°, the whole eastern face is resplendant with freshly formed snow, yet not quite so brilliant as at the higher levels, perhaps because on the lower and steeper slopes small projections of rock more frequently interrupt the bright surface. Spot *c* has greatly increased in size, *a* has diminished by melting away from the eastern end of the ridge, while new spots have formed at *d*, *d'*, *e*, *f*, and *g*. Spots *d*, *d'*, *e*, and the western ends of *b* and *c* were distinctly greenish, and this appearance frequently occurs when the formation of snow is very light, due perhaps to small scattered patches. The effect may be subjective, although it does not look as if it were. Spots *f* and *g* were the brightest of the southeastern patches, a supremacy which the southern one, *g*, soon loses under the influence of the direct summer sun.

The next night, 68.2°, spot *a* had returned to the eastern end of the ridge, increasing slightly in size at the same time; *b* and *c* had diminished, the latter notably; indeed *c* varies more in size and shape than any other spot on the mountain. This is quite natural since it lies on a wide comparatively level region, with a southern exposure. In fact it had broken into several smaller pieces which are shown in the drawing made on the following night. Changes were suspected between drawings made early and late in the evening. Spot *e* had increased in size but not in brightness. Spots *d* and *d'* had now united, but *d* was distinctly the brighter of the two.

An interesting phenomenon is exhibited at this colongitude, when spots *a* and *d* begin apparently to steam. In a few hours thick clouds of vapor are thrown off, especially from *d*, so that its outlines become very hazy, and quite different from its earlier and later appearance, and from the other spots about it. Its color becomes decidedly bluish, and the fog or mist in a thin transparent stream is swept off across the *mare* to the south, as indicated in figure 9. The action becomes less violent about colongitude 90° and by 95° has ceased altogether, as a usual thing, although it was observed on one occasion at the base of *d* as a very faint haze as late as 115°. All the spots have occasionally been recorded as slightly hazy at about this time, but none of the others are at all comparable in this respect to *d*. At colongitude 76.8° the ridges of Teneriffe have been recorded as steaming from end to end. In the meantime neighbouring bright spots were perfectly sharp and distinct. This steaming might be either a case of melting snow or of volcanic activity, the steam condensing into ice crystals and falling as snow. The writer rather favors the latter view, since the other spots do not exhibit it.

Knowing what to expect at this colongitude, *d* was carefully examined early in the evening at 68.8° and was recorded as "not notably hazy." At 70.0° it was recorded

"*d* and *d'* rather indistinct, *d* the most so, but not as hazy as they have been seen." At 70.1° "*d* is now clearly hazy." The next night at 81.9° "all spots are more or less hazy, but *dd'* especially so." Where the steam flows away at the base of the mountain across the *mare* it is extremely faint.

The following are all the other records that have been made pertaining to the haziness of *d*.

September 23, 1912. 64.8°. No steam from Piton or Pico *B*, but Pico sending a thin streak south from *d*.

February 18, 1913. 65.4°. The "snowstorm" has begun on *a* and *d*, but *d* is very faint, greenish, and quite separate from *d'*.

December 21, 1912. 69.3°. The snowstorm has begun. *d*, *e*, *f*, and *g* are all hazy and bluish, but *d* much the most so, while *a*, *b*, and *c* are very sharp.

March 20, 1913. 71.4°. Pico *d* and *d'* enveloped in cloud.

August 25, 1912. 72.0°. Pico is perhaps beginning to steam.

November 22, 1912. 74.4°. Pico. Snowstorm on the northeast peak (*d*) well developed, bluer than the other peaks. The northern peak (*a*) shows the same to a less marked degree. 74.6°. Snowstorm wonderfully well developed.

September 24, 1912. 78.5°. Pico *d* is very foggy as compared to *b*, *c*, *e*, *f*, and *g*. Spot *a* is a little foggy, but nothing like so markedly so as *d*. The contrast between *d* and *f* especially is very striking.

December 22, 1912. 81.8°. Pico. The snowstorm on *d* still continues, but it is not so hazy to-night.

August 26, 1912. 84.1°. As compared with last night, 72.0°, *d* has grown larger and more fuzzy.

March 21, 1913. 84.4°. Pico *d* is still a trifle brighter than *f*. It is a little more hazy.

January 21, 1913. 86.0°. Pico, storm at *a*, *b*, *c*, *d*, and *d'*.

September 25, 1912. 90.4°. All the spots except *c*, *e*, and *f* are as hazy as *a*; *d* no more so than the others.

December 23, 1912. 94.3°. Pico *d* is now much the brightest. The snowstorm is over.

January 22, 1913. 97.8°. Pico *a* and *d* have increased in size and are still a trifle hazy.

November 27, 1912. 99.5°. Pico *d*. Cannot be sure if the haziness has disappeared. 100.5°. Think the snowstorm still continues, but has diminished.

September 26, 1912. 103.3°. All the spots are sharp.

August 28, 1912. 109.5°. A very faint haze extending south from *d*.

November 25, 1912. 113.2°. The snowstorm has ceased.

September 27, 1912. 115.2°. The base of *d* and *d'* is perhaps a little hazy, but all the rest of the mountain seems clear, including Pico *a*.

September 28, 1912. 126.7°. All the bright areas on all the mountains seem to be sharp.

The "snowstorm" referred to in several of these extracts is a possible explanation of the phenomenon observed, since, as it progresses, *d* gradually becomes brighter than before and sometimes larger. At the same time *d* is clearly shown, with sharp borders, one day before the general haziness usually appears. Moreover, some of the other spots, notably *f*, are equally bright with *d*, and only on the rarest occasions appear hazy.

In figure 4, colong. 81.8°, the notable changes from the previous one are the coalescing of spots *d* and *d'*, and the breaking up of *c* into small pieces. Spot *e* has broadened and grown brighter, gradually advancing toward the east. No marked change occurs for the next three days, save that the haze on the *mare* at the foot of *d* becomes more distinct. At the end of that time, at colongitude 115.1°, spots *a*, *b*, and *c* are found sometimes to have shifted their position angles so as to lie nearly northwest and southeast. Spot *a* does this by gradually working its way around the northern corner of the mountain. Spots *b* and *c* change more suddenly. On January 31, 1915, at colongitude 106.7°, spot *b* had disappeared.

In figure 5, 126.7°, an entirely new though faint spot, which we have called *h*, has formed midway between *a* and *f*. This drawing is the only one which has been secured of it. The previous night a drawing was made showing all the other eight areas, but nothing in the place of *h*. The following night *c* had disappeared and the brightness of all the other areas is recorded, but no mention is made of it. Moreover, neither the drawings and estimates of brightness made December 25, 1912, 118.7°, and December 26, 1912, 130.4°, nor figure 6, made January 31, 1915, 132.2°, show any trace of it, although it was looked for carefully on the latter night. It has been seen on one or two occasions during the past year.

An examination of figure 6, 132.2°, shows clearly the location of two ridges situated on the western flank of the mountain, whose shape explains in part the forms of spots *b* and *c*. By colongitude 147.9° the sun has set on the western slope, and in that drawing and at 159.3° the appearance is very similar to that at 183.6° when figure 7 was drawn. The chief difference is that in the earlier drawings the spots *d*, *d'*, *e*, and *f* all reached down to the level of the *mare*, while in the later one at 183.6° *d'*, *e*, and *f* have already begun to melt and disappear at their bases. This does not always happen, however, for on October 3, as late as 189.5°, *d*, *d'*, and *e* are all shown as reaching down to the level of the *mare*, the terminator at this time passing through the base of the mountain.

As the result of observations made on 29 dates, extending over two years and a half, and lying between colongitudes 7.1° and 189.5°, we may summarize our results and state that spots *a*, *b*, and *c* first became visible at sunrise with full brilliancy 10, and that *d*, *d'*, *e*, *f*, and *g* appear at 56° with brilliancies 6 to 8, some two days after the sun first reaches the eastern side of the mountain. At about 80° these latter points brighten, but with the exception of *d* never reach full brightness. Just before this *d* becomes very hazy for a couple of days and *a* less so. At 100° *a*, *b*, and *c* begin to fade and at 130° the two last disappear, the sun setting upon that part of the mountain about two days later. At 130° *g* begins to fade, but all the spots save *b* and *c* are visible until near sunset. Spot *h* appeared once for a short time at 127°. Spot *c* is the one which varies most in size and shape during the lunation and also from one lunation to another. Its variations are most marked between colongitudes 45° and 70°.

Other mountains in this immediate vicinity carry spots of variable size, and also present other features of interest. Just to the south of Pico, in longitude 9°, latitude +43°, lies the long elevated ridge Pico *B*, not to be confounded with the crater Pico B, located beyond the Teneriffe Mountains. "*B*" rises at the western end to a height of 5000 feet above the surrounding plain, and is about 10 miles in length. On account of its isolated position it is visible in nearly its entire length at colongitude 7.1°, the western end and middle peak being brilliant with snow. These spots are very persistent, and by 56.2° are more conspicuous than anything on Pico itself. The northeastern side of the ridge is now beginning to show, and by 69.8° is clearly seen. On July 23, 1912, 26.6°, it is recorded "the upper slopes of Pico and nearly the whole of *B* are as bright as the brightest summits of the Alps." This certainly was not the case on January 24 or 25, 1915, 19.8°, 33.6°, when the two spots were but little larger than indicated in figure 8. On September 23, 1912, 64.4° (fig. 8), a small but easily seen white spot, one mile from top to bottom by one quarter of a mile in width, lay upon the southern slope of the mountain halfway between the two larger spots. It was visible also September 24 and 25, 78.5°, 90.4°, but the next night, 103.3° had disappeared. This spot was also visible August 26, 1912, 84.3°, but the next night had vanished. It did not appear this year at all, but on January 28, 69.8°, a faint line of snow lay along the crest of the mountain connecting the two large spots, thus lying at right angles to that seen in 1912. The next night the line of snow had already begun to melt at both ends, thus severing its connection with the spots.

A curious feature which shows well on this mountain appears at or a little earlier than 69.8°. This is a row of almost contiguous bright dots which make their appearance along the eastern portion of the southern base (see fig. 8,) just where it rises from the plain. They are never very bright, seldom exceeding 7, but they gradually extend further toward the east. Two nights later another row extending the whole length of the northern base is also seen. Similar rows line both sides of Schroeter's Valley near Aristarchus, as also the rills of Hyginus and Ariadæus, although the last is rather faint. They look like columns of steam or cloud, and it is possible such may really be the case, as these are just the locations where hot springs occur in the case of the earth. If they are due to springs of water they need not necessarily be hot, since on account of the low atmospheric pressure, water would boil at the freezing point, 32°F., on the moon. Whatever their explanation, they form it is believed a hitherto undescribed feature of the lunar landscape.

On September 25, 1912, at 90.4°, Pico *B* was steaming vigorously at its eastern end, the steam drifting off across the *mare* toward the north. This is the only record we have of steam clouds from this mountain. On February 2, 1915, 132.4°, the western spot had vanished, while that at the middle was faint. September 29, 1912, at 139.9°, it too had gone. Somewhat earlier, spots had appeared on the north-eastern face, and one near the middle was quite conspicuous on August 31, 1912, at 148.1°. Nothing of the sort was seen February 3, 1915, at 146.6°. On September 1, 1912, at 166.2°, a second smaller spot appeared just west of the other. The southwestern slope of the mountain was still visible, but the next night was enveloped in shadow, and another small spot had appeared on the northeastern side. This was our latest observation of it.

While these observations are all easy enough here in Jamaica, it is undoubtedly true that many of the phenomena recorded would be difficult with the inferior atmospheric conditions existing in the north. It has, therefore, always been the writer's aim to find and describe the most conspicuous changes that he has been able to detect. A marked irregular change recently occurred in Eimmart, and has been described by him in Astronomische Nachrichten no. 4704, but there are regular changes constantly occurring within that crater, in some cases differing from one lunation to another, of about the same degree of visibility as those observed upon Pico.

With his 3-inch finder and a magnification of 180 he has been able to see clearly spot *d*–*d'* on Pico, and to suspect *f*, at about the time of full moon. With a somewhat larger aperture these and perhaps some of the others should be visible in the north, so that it should be possible to record the times of their appearance and disappearance. The same should be true of the two spots on Pico *B*.

Among the most difficult observations to confirm would probably be those relating to the so-called snowstorm on Pico *d*. Where the seeing is continually bad, all outlines are indistinct and therefore little difference would show even between *d* and *f*. Where, on the other hand, two or three diffraction rings are almost stationary around the brighter stars, with the full aperture of 11 inches and a magnification of 800, as occurs here with our best seeing (S. 12), it is plain that details on the moon present a sharpness of outline quite unknown in the north. That certain bright spots such as Linné are always hazy, is well known. The peculiarity of Pico *d* is that it is hazy only at specified seasons on the moon, when other neighboring and similar spots are sharp.

There are, however, other objects on the moon similar in their characteristics to *d*, which are much easier to observe. One of these is Sulpicius Gallus *B*, so designated on Goodacre's map, but not shown by Neison. The crater is located in longitude 351°, latitude +20°. On its eastern interior wall there is an intensely brilliant pear-shaped spot, very conspicuous just before full moon. It clearly changes its shape at different times, and is very hazy and indistinct between colongitudes 30° and 120°, although sharply defined earlier and later in the lunation. The duration of the indistinct period is thus much greater than on Pico *d*, and the change in appearance is so marked that the writer feels convinced it should be capable of detection in the north.

It has recently been found that the western end of the Straight Range presents changes that are fairly conspicuous. The sunlight first strikes it at colongitude 20°. It is then intensely brilliant, especially at its northern edge. By 44° it is rather less bright. By 70° all the snow has gone except at the north and the bare rock, of brightness 6, looks red in contrast with the greenish *mare*. At colongitude 82° faint whitish streams, of brightness 7, begin to cover the rocky face. These have further brightened by 90°, but by 103° have again largely disappeared. The formation has been under observation for so short a period, however, that this description should be looked on merely as an indication of what may be expected rather than as a finished report of what generally occurs.

Turning now to quite a different type of formation, we find scattered over the moon's surface, but specially in the equatorial regions, a series of small craterlets whose interior walls under all illuminations are of dazzling brilliancy. The floors of the smaller ones are also bright. One of the best known of these is Mösting *A*, some 5 miles in diameter, 3,000 feet deep, and situated in longitude 5°, latitude −3°. On January 27, 1915, at colongitude 56.3°, the shadow still showed within the crater but had entirely cleared the center of the floor, which appeared of a uniform brilliant white without detail. On March 19, 1913, 61.0°, a minute black dot of less than half a mile in diameter was detected at the center. It was also observed February 18, 1913, 66.0°. On January 28, 1915, 70.1°, the dot was clearly seen, was about a mile in diameter, and was of the same darkness as the region surrounding the crater. Accompanying the dot, and reaching from it toward the north, three-quarters of the way up to the rim, was a faint dark band 1 mile in breadth. This was observed March 20, 1913, 71.4°, though of slightly greater breadth and much greater density, and also on January 29, 1915, 82.0°. No change was detected March 21, 1913, 85.7°, but February 2, 1915, 132.5°, the shadow had appeared on the eastern side, and the canal [or band] had almost completely faded away. The next night both the canal [or band] and central dot had vanished, and the floor was a uniform white. The crater is clear of shadow for about 70° of colongitude. Herschel *c* and Lalande *D* exhibit similar peculiarities. In *c* the canal extends toward the west, and in *D* northwest. In all cases as the sun rises higher and higher upon them the snow melts, and after midday forms again.

We will turn now to another type of white spot, the only one which has been investigated micrometrically. We refer here to Linné. An account of it is given in the Harvard Annals, **61**, 100, where measures by the writer in 1897, 8, by Prof. Barnard in 1902, 4, and by Prof. Wirtz in 1904, 6 are compared. All three agree in showing a marked diminution in size as the luna-

tion progresses, up to a certain point, and after that an increase. According to the first two, the minimum size is reached at about 12° past midday for Linné, and the diameter about sunset is slightly less than about sunrise. Prof. Wirtz, on the other hand, finds the minimum size occurs 12° before midday, and the diameter at sunset to be much larger than at sunrise, which would indicate a certain melting during the lunar night. All three agree, however, that the diameter fluctuates through a range of about 3″. Irregular changes in the shape of the spot and its surroundings were noticed by all three observers.

Thus, Prof. Barnard, on September 1, 1903, detected a small bright point preceding the spot, 5.4″ from its center. On February 12, 1905, Prof. Wirtz saw two irregular, extremely delicate, bright offshoots on the otherwise well-rounded spot; the next day these offshoots had disappeared, leaving the spot slightly elongated. Other observers besides the writer have found the size of the spot to increase slightly at the time of a lunar eclipse, so that a certain amount of literature upon the subject has already accumulated.

Mr. J. G. Burgess, of the British Astronomical Association, has recently called my attention to a spot situated some 12 miles north of Littrow *B*, in longitude 330°, latitude +22°, which is of the Linné type, and according to his description should be of greater interest than Linné itself at the present time, since it contains considerable fine detail close to the crater. His statements are in part confirmed by the writer's Photographic Atlas.[4] Mr. Burgess proposes soon to publish an account of his observations, the results of which in general resemble those made upon Linné. The writer examined the region February 2, 1915, at 132.8° and found covering it at that time a very thin white veil whose density was 0.2 of a unit of brightness. This veil was 6 miles in diameter. The next night it had entirely disappeared. This spot should be of particular interest at the time of a lunar eclipse, since the detail near the crater should make drawings available, thus avoiding some of the subjective systematic errors incident to micrometric measurements.

Conclusion.

It has been the writer's object in the present article to show, not that periodic changes occur in the brighter regions of the lunar surface, for that was known before, notably in the case of the region surrounding Tycho, but to show in just what these changes consist. For this purpose he has selected small bright spots lying in regions showing sharply defined minute detail, in order that the minute changes everywhere occurring upon the moon could be more clearly defined. In order to make the study general, he has also selected the three different types of surface—elevations, depressions, and level areas.

The point of first interest, perhaps, in this investigation is to find when the spots reach their minimum size. Within the craters the dark areas appear and disappear at about the same interval before and after midday, which therefore seems to be the time when the snow presents the smallest area. In the case of Linné, Prof. Barnard and the writer agreed that the minimum occurred one terrestrial day after lunar midday. Since the deviations of their observations from their respective curves were appreciably smaller than those of Prof. Wirtz, doubtless due to better atmospheric conditions in America, and since a minimum occurring after noon seems more probable than one occurring before it, the writer has adopted that view. It would certainly be of interest to prepare a series of drawings of the craterlet near Littrow *B* and determine when its minimum occurs. In the case of Linné and apparently also of Littrow, the white spot is invisible both at sunrise and sunset. Just why this should be so is not very clear, but it would seem to indicate that the moisture can only escape from the vent about midday, and that toward sunset it all evaporates. Toward noon the evaporation occurs before it can get far from the vent; hence the spot is smaller, although brighter at that time than earlier or later.

In the case of the mountains, Pico, Pico *B*, and Straight Range, most of the white spots grow smaller the longer the sun shines on them. Those on the west side of the mountains, toward the rising sun, are of full brightness when the sun first strikes them. Those on the east do not deposit until the sun has been shining on the region for a day or two. It appears as if the ground some little way beneath the surface must be heated up before the moisture can escape. The spots on the western side, on the other hand, must be formed very shortly after the sun sets on them, but while it is still daylight in the surrounding region, for it is clear that nothing can deposit during the night, or both sides of the mountain would be brilliant when the sun first reached them. Pico *c* was seen in January, 1915, distinctly to grow in size and spread over the dark surface of the mountain between colongitudes 9.0° and 16.6°. It then decreased in area until 32.9°, figure 2, after which it increased a second time in size until 55.9°, figure 3, and then rapidly diminished until 68.1°. It had not changed at 81.8°, figure 4, but when the region was next observed at 132.2° the spot was found to have disappeared.

The writer has sometimes been asked, "*What reason is there to believe that there is ice upon the moon?*" The answer is: "For the same reason that we believe there is ice upon Mars, because the phenomena observed can be more readily explained that way than any other." Whether the ice is deposited upon the surface or floats as inute crystals just above it in the form of surface clouds o fog, is not yet clear, but it is believed it occurs in both rms. Where the boundaries are sharply defined it lies pon the surface. Where the boundaries are indistinct and hazy—as, for instance, in the case of Linné—it is still uncertain. In the case of the bright rays surrounding Tycho, it is thought the ice crystals are supported in the lunar atmosphere like those terrestrial cirrus clouds to which we give the name "mare's tails."

[4] Annals, Harvard College observatory, v. 51.

AGRICULTURAL METEOROLOGY.[1]

J. WARREN SMITH, Professor of Meteorology.

[Dated: Weather Bureau, Columbus, Ohio, 1915.]

(Author's résumé.)

In this paper agricultural meteorology is defined as meteorology conducted in the interest of agriculture. A part of agricultural meteorology is agricultural climatology, which shows the effect of climate upon the geographical distribution of vegetation and the adjustment of farm activities.

[1] Read before Section IIB, Second Pan-American Scientific Congress, Washington, Dec. 28, 1915. Will appear in full in the special publication issued by the Ohio Academy of Sciences on the occasion of its twenty-fifth anniversary.

Russia has apparently taken the lead in trying t determine the most critical period of growth for field crops, although Canada has recently started investigations along similar lines.

The United States Weather Bureau has long maintained special services in the interest of agriculture which may be classed under agricultural meteorology, such as the special corn and wheat region service, cotton and rice service, fruit service, etc.

The personal investigations of the author have been to find the critical period for farm crops and the weather most affecting them by correlating the crop yields with the weather conditions for periods long enough so that accidental coincidences will be eliminated.

This has been done graphically by the curve chart and the dot chart, as well as by the mathematical calculation for giving the exact measure of relation between two factors, as expressed in the correlation coefficient.

The crops considered in this paper have been corn, potatoes, and winter wheat, and the periods covered between 50 and 60 years.

Most of the correlations have been made between the yields and the temperature and rainfall for calendar months and groups of months. From these correlations it has been found that the most important weather factor for corn is rainfall and the most important month July. For potatoes the most important factor is temperature, and the critical month is also July. March is the critical month for winter wheat and temperature is the most important weather factor.

The critical rainfall point for July, in its effect upon the corn yield, is 3 inches. It is found that a variation in the rainfall of one-fourth inch in July in Ohio at this critical rainfall point makes a variation in the corn yield of nearly $3,000,000, and a variation of one-half inch in the rainfall a variation in the yield of over 15,000,000 bushels. In the four greatest corn States of the central part of the United States a variation of one-half inch of rain at this critical point makes a variation in the value of the amount of corn raised of $5 an acre, or a total of $150,000,000.

When the rainfall in Ohio in July is more than 1 inch above the normal the probability of the corn yield being above the normal is 92 per cent, and when the rainfall is 1 inch or more below the normal, the probability of the corn crop being above the normal is only 13 per cent.

While July must be wet and moderately warm for the best crop of corn, it must be cool and moderately wet for the best development of potatoes. If July averages more than one degree a day warmer than the normal the probability of the potato crop being above the average is only 12 per cent. When the temperature has been above the normal and the rainfall more than one inch either greater or less than the normal, the yield of potatoes has always been less than the normal.

Weather effects for shorter periods than months have been determined, and it has been found that the most important 10 days for corn is immediately following blossoming, when it must be wet and moderately cool. For potatoes the 10 days following blossoming must be cool and should be moderately wet. For arbitrary 10-day periods the most critical for corn is from August 1 to 10, and for potatoes from July 1 to 10.

In connection with winter wheat it is found to be much more difficult to determine the dominant weather factor as well as the critical period of growth for any all-seeded crop or one with a long growing period than for spring-seeded crops or those with a comparatively short-growing period.

Careful correlations between rainfall for months and groups of months and the yield of winter wheat in Ohio show that the rainfall is neither too great nor too little often enough to have an appreciable effect upon the yield in calculating for the correlation coefficient.

Neither are the temperature variations great enough to show a dominating effect except for the month of March. If we consider only those years when the mean temperature has varied two degrees or more a day from the normal the probability of a wheat yield being above the normal is 94 per cent with a warm March and only 25 per cent with a cold March.

It is customary to credit a good snow covering with a good yield of winter wheat or to say that a lack of snow blanket is sure to cause a poor yield. But careful correlations made in Ohio seem to show no beneficial result from a snow covering or damage from lack of it. At least the snow covering does not have a dominating influence. On the other hand, the studies seem to show that bare ground with freezing and thawing weather in January is beneficial.

Further, while a snowfall in January seems to be favorable it is found, contrary to the usual opinion, that snowfall in March is decidedly detrimental to winter wheat. In several counties of the State it has been found that in nearly every instance the greater the snowfall in March the less the wheat yield, and that when the snowfall is light the yield is nearly always above the normal.

It is believed that one of the first developments of agricultural meteorology should be to find the critical period in the growth of the various staple crops in different sections of the country, and that when these are found all farm activities can be put on a much more profitable basis.

Those who irrigate in the western districts will know better just when to apply the water for the best results, and farmers in the central and eastern districts will learn that it will pay to aid natural rainfall by irrigation.

It is believed that this new agricultural meteorology when properly developed will enable us to express rainfall in terms of cash value rather than in inches, temperature in the ability of the farmer to buy instead of in degrees, and sunshine in the increased number of automobiles and tractors rather than in calories.

BREATHING WELLS AND PRESSURE CHANGES.

Mr. John Free, of New Carlisle, Clark County, Ohio, has kept a daily record of the "breathing" of his well (see this REVIEW, Nov., 1915, p. 562) through the month of February, 1916, and has sent it to this bureau with the remark "In looking over the high and low pressure maps for November I see that none crossed Ohio; but my well was active just the same."

This record is very interesting for it permits us to compare the subterranean conditions with the pressure-changes going on at the earth's surface and recorded at our Weather Bureau stations. The following table presents Mr. Free's observations, and in addition the 12-hour changes in pressure at Columbus, Ohio, as telegraphed to the central office at 8 a. m. and 8 p. m. daily.

TABLE 1.—*Record of breathing well at New Carlisle, Ohio, and pressure-changes at Columbus, Ohio, February, 1916.*

Date.	Weat	Well blew—		Remarks.	Columbus, Ohio, 12-hour pressure-changes.	
		A. M.	P. M.		8 a. m.	8 p. m.
Feb. 1	Fair	In.	In.		0.28	0.16
2		Out.	Out.	Snow flurry at night	−0.12	None.
3		In.	In.		0.10	0.08
4		In.	Out.	In to 9 a. m.; out at 1 p. m.	0.08	−0.18
5		Out.		Out till evening	−0.22	−0.04
6	Snowing	Out.		Stopped blowing in evening.	−0.22	None.
7		In.	Quiet.	Quiet at 8 p. m.	0.26	0.26
8			Out.		−0.06	−0.34
9		Quiet.	In.	Quiet at 9 a. m.	0.06	0.24
10		In.	Out.	In till 9 a. m.; out at 1 p. m.	0.08	−0.02
11	Raining	Out.	In.	In at 4 p. m.	−0.14	−0.14
12				[No record]	−0.10	0.12
13	Snow flurries	In.	In.	Snow flurries, p. m.	0.22	0.24
14		In.	Out.	Out at 4 p. m.	0.10	−0.06
15		Out.	Out.		−0.08	−0.16
16		Out.	Out.		−0.18	−0.22
17		Out.	Out.		−0.06	−0.04
18	Blizzard	Out.	In.	In at 3 p. m.	−0.16	0.28
19	Snowing	In.	Out.	Out at 1 p. m.	+0.10	−0.10
20		Out.	In.	In at 1 p. m.	−0.24	0.24
21		In.	Out.	Out in evening.	0.34	−0.10
22		Out.	Out.		−0.16	−0.20
23		Out.	In.	Out until 9 a. m.; in in evening.	−0.06	0.10
24		Out.	Out.		−0.14	−0.06
25		Quiet.	Quiet.		−0.06	0.10
26	Snowing	Out.	In.	Out until 2 p. m.	−0.16	0.06
27		In.	In.		0.22	0.14
28		In.	Out.	In until 2 p. m.	0.06	−0.14
29		Out.	In.	Out until 9 a. m.	−0.04	0.16

Columbus, Ohio, is about 55 miles (87 kilometers) almost due east of New Carlisle, and its pressure changes may be taken as sufficiently representative of those taking place at New Carlisle to serve for comparison with the well breathings. It appears from Table 1 that, out of 56 recorded pressure-changes and well "breathings," *rising pressure-changes* were accompanied by inspirations 22 times and no breathing in 4 cases, while *falling pressure-changes* were accompanied by expiration 27 times and by no breathing only twice. On one occasion (afternoon of the 11th) there seems to have been a case of inspiration during apparent falling pressure, which may represent an occasion of temporary rise in pressure between the two telegraphic reports given in the table.

The table will make it plain that even though the daily weather maps show no *centers* of high or of low pressure passing directly over Ohio, and certainly not over New Carlisle, nevertheless the atmosphere over the State was constantly varying in pressure as storms traveled across the country. Thus, from the morning of the 1st to the evening of the 4th of February, 1916, Mr. Free's well was taking in air, predominantly, while the synchronous pressure changes were predominantly positive. This was under the influence of the general rise in pressure due to the eastward movement of the high area whose crest occupied the Dakotas, Nebraska, and Kansas on the morning of February 1, but had moved across Ohio to West Virginia by the morning of February 4.

Again on February 13–14 the well was breathing in under the influence of a slightly rising pressure which changed to falling pressure on the afternoon of the 14th, and the well exhaled continuously for four days as the pressure steadily fell before the advance of the southern periphery of a great low whose center never came south of the Great Lakes. During this period Ohio was always on the southern skirts of the depression; the center of the low did not pass over Ohio.

Applications of this phenomenon.—This relation between pressure-changes and earth breathing has been recognized and studied for some time. Private efforts have been made in England, and to some extent in this country, to utilize the pressure-changes in forecasting conditions favorable to explosions of gases in mines. England has not yet made public efforts to forecast such conditions for the benefit of the mine operators, but Dr. W. N. Shaw, Director of the Meteorological Office, has outlined a scheme looking toward the preparation of such forecasts.[1] In the United States the Weather Bureau does not issue official forecasts or warnings of conditions producing mine explosions; but it authorizes certain of its local forecasters to telegraph marked changes in pressure to the mine operators and thus enables the latter to form their own conclusions as to the probability of danger.—C. A., jr.

ALTO-CUMULUS WITH VIRGULUS.

The cloud form illustrated by a rough sketch in the REVIEW for December, 1915, page 614, but more properly called "alto-cumulus with virgulus" (as was pointed out by Prof. Talman in the issue for January, 1916, p. 23), seems to be better known in the United States than our first correspondent thought.

Mr. J. B. Willsea, of Fruita, Colo., writes under date of March 25, 1915,—

> This class of clouds is seen frequently in this valley [Grand River], especially in the spring when we are watching for frosts that damage our fruit blossoms.
>
> Possibly some may be interested in the shape of these clouds as we see them here. I will try to make sketches of them this spring.

Mr. Willsea calls our attention to the fact that these clouds were described and sketched but not specifically named at Blue Hill, Mass., as long ago as 1888. The following is taken from H. H. Clayton's "Discussion of the cloud observations:" [2]

> The formation of cirrus from clouds of the cirro-cumulus or alto-cumulus type has been repeatedly observed. Figures *m*, *n*, *o*, *p* [op. cit., Plate VI], are all taken from rough sketches made by the writer at the time of observation. These forms apparently all resulted from descending cloud particles. The heavy particles fell fastest, and succeeding particles followed the same path on account of the less resistence, and thus formed long fibers which were usually carried backward from the cloud on account of the decrease of wind velocity with lower altitude. The form *m*, with fibers suspended nearly vertical, was observed on several occasions, and care was taken to ascertain that the apparently nearly vertical direction of the fibers was not an effect of perspective. As a rule, the suspended fibers were bent backward in the direction from which the cloud moved, as shown in *n*. On watching these clouds it is seen that the fibers move continuously outward from the clouds, until the entire cloud is drawn out into pure cirrus. Several times cirrus (!) were observed to elongate from the top of cirro-cumulus clouds, as shown in figure *k*, Plate VI, from a sketch made July 3, 1888, the cirrus being apparently drawn outward by a more rapid current at the top than at the base of the cirro-cumulus. Similar formations of cirrus from the tops of the cirro-cumulus bands were observed on several occasions.
>
> The writer has also repeatedly seen cirrus-like fibers drawn out from small cumulus clouds, sometimes from the top and sometimes from the base of the cloud, and once from both at the same time, thus giving the the cloud a very fibrous appearance. Most of these cases occurred during the latter part of winter or in the spring, and usually accompanied the setting in of a very low temperature, sometimes below zero Fahrenheit. These clouds appear to float at the same altitude as ordinary cumulus. The following note of measurements made on the velocities and altitudes of this type of cloud was recorded on March 30, 1894: "At 3 p. m., one or two large cumulus in the south had cirrus-

[1] See his "Forecasting weather". London, etc., 1911, pp. 306-312.

[2] Observations made at the Blue Hill Meteorological Observatory. Discussion of the cloud observations, by H. Helm Clayton. Cambridge, Mass., 1896, pp. 387-388. (Annals, Astronomical Observatory, Harvard College, 30, pt. 4.)

like fibers extending from base and summit. From several measurements of the velocities of the shadows of these clouds the base was found to have a velocity of 15.0 meters per second, and the top about 17.8 or 18.0 meters per second (determined from the velocities of the rear and the front of the shadows respectively). These, combined with measurements of the angular velocity of the cloud, give an altitude of 1,820 meters for the base of the cloud above Blue Hill. The altitude, determined in another manner from the position of the cloud shadow and the angular altitude of the cloud, was calculated to be 2,200 meters above the hill."

SEVERE ICE STORM IN MICHIGAN.

The Weather Bureau storm-warning displayman at St. James, Beaver Island, Mich., Rev. Edward J. Jewell, reports that a severe ice storm visited his station at the close of January, 1916. He writes, in part, as follows:

During the night of January 27 a great weight of sleet accumulated [on the halyards of the steel storm-warning signal display tower] and the heavy wind drove them over—all four—to one side of the [steel] mast, bending the mast down almost upon the tower itself. The sleet crushed nearly all our most beautiful trees, quite stripping the pines of all branches. For days the clashing of trees was heard everywhere. We never saw such a fearful sleet. The halyards were over 4 inches in diameter. I could not shake off the ice. We have 2 inches of the ice sheet still on the ground (March 4). It has ruined seeding, sending frost down 5 feet into the ground, freezing up our water pipes. It heaved the house at night like an earthquake rocking it.

One of the halyards broke and fell after the pole was bent. All the damage was done before daylight. * * * I saved the windmill by shooting the ice with a shotgun. The phone wires did not break, but the wires to Cross Village are down. I broke the ice from the wires when they became weighted down within reach. All the old wires broke on the old phone.

32793—16——2

ARTHUR WILLIAMS WRIGHT, 1836–1915.

Prof. Arthur Williams Wright (*b.* Sept. 8, 1836), who died at his home in New Haven, Conn., December 19, 1915, was the designer and founder of the first physical laboratory (as we now understand that institution) in the United States, viz, the first Sloane Physical Laboratory of Yale College. This laboratory was completed in 1883, and in 1884 it was one of three stations established under the direction of the Chief Signal Officer (Gen. W. B. Hazen) for the study of atmospheric electricity. Mr. Oliver L. Fassig was detailed to the station and carried on its work for nearly two years, until its discontinuance; but the work in atmospheric electricity was continued in the Sloane Laboratory and the observations have been one of the regular exercises of the students there.

Thanks to this enthusiasm the laboratory secured atmospheric potential observations just before and just after the eruption of Mont Pelée (May 8 and 9, 1902), and these observations were discussed by Prof. Wright in this REVIEW, June, 1905, **33**:241–242.

Prof Wright contributed important papers on the zodiacal light, on the polarization of light from Coggia's comet, and on the gaseous contents of meteoric irons and stones. He was one of the very earliest in this country to repeat, verify, and extend Röntgen's discovery of the X-rays. An appreciative notice of his work is printed by Prof. Charles S. Hastings in "Science" (New York) for February 25, 1916.—C. A., jr.

SECTION III.—FORECASTS.

FORECASTS AND WARNINGS FOR FEBRUARY, 1916.

By EDWARD H. BOWIE, District Forecaster.

[Dated: Weather Bureau, Washington, Mar. 20, 1916.]

There will be found in the MONTHLY WEATHER REVIEW for January, 1916, statements concerning the abnormal cold in the Northwestern States, the northern Rocky Mountain Region, and the Pacific States, and the comparatively mild weather that month in much of the country east of the Mississippi River and in the West Gulf States. In the Northwestern States the month of January was one of the coldest on record, and at a number of points minimum temperatures as low as or lower than ever before recorded occurred in that region. Moreover, the cold in that region continued during the first decade of February, but soon thereafter the prolonged cold weather in that region gave way to temperatures above the seasonal average, and such temperatures continued generally west of the Mississippi River through the remainder of the month, while east of the Mississippi River February gave temperatures that averaged below the normal. Without attempting to offer an explanation as to the ultimate cause of the unusual temperature conditions referred to in the preceding paragraph, it is of interest to note that during January the pressure averaged extraordinarily high over Alaska and the Aleutian Islands and the western Atlantic Ocean, and low over the middle latitudes of the Pacific Ocean as shown by the daily reports from Honolulu, Hawaii. It has been noted on innumerable occasions that when the barometer falls at Honolulu the pressure rises over the north Pacific Ocean and Alaska, and all pronounced cold waves of the United States are commonly associated with this "upset" pressure distribution. May it not be assumed that when there is an excess of heat within the Tropics the pressure falls, the air through a considerable distance expands and rises, and the rising air flows away horizontally to the north and south, and descends in higher latitudes and produces the abnormal pressure conditions referred to as having prevailed over Alaska and the Northwest during the whole of January and the greater part of February. It will be recalled that in MONTHLY WEATHER REVIEW Supplement No. 1 the statement was made that cold weather in the interior of the United States is associated with high barometer over Alaska and the Aleutian Islands, and that warm weather in the winter months in the Eastern and Southern States is to be expected when the barometer stands high over the western Atlantic Ocean as indicated by pressures recorded at Bermuda. The recorded temperature conditions over the United States during the month of January afford a striking confirmation of these statements. The graph, figure E.H.B. 1 (XLIV—21) illustrates the abnormalities by showing the daily departures from the normal pressure at stations in these regions during the two months in question, and Table 1 herewith gives the monthly average pressures and their departures from the normal for all Alaskan stations, Honolulu, Hawaii, and Hamilton, Bermuda.

TABLE 1.—*Mean pressures for January and February, 1916, compared with the normals for those months.*

Station.	January.			February.		
	Normal.	Mean, 1916.	Departure.	Normal.	Mean, 1916.	Departure.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Honolulu, Hawaii	30.01	29.90	−0.11	30.04	29.99	−0.05
Nome, Alaska	29.87	30.29	+ .42	29.80	30.08	+ .28
Dutch Harbor, Alaska	29.63	30.16	+ .53	29.60	29.78	+ .18
Tanana, Alaska	29.94	30.42	+ .48	29.86	30.14	+ .28
Valdez, Alaska	29.73	30.19	+ .46	29.78	29.90	+ .12
Eagle, Alaska	30.03	30.51	+ .48	29.98	30.22	+ .24
Sitka, Alaska	29.73	30.05	+ .32	29.82	29.91	+ .09
Hamilton, Bermuda	30.13	30.34	+ .21	30.09	30.14	+ .05
Horta, Azores	30.14	30.26	+ .12	30.10	30.39	+ .29

The data shown in the graph and the table also confirm the statement that there is a direct relation between the observed sea-level pressures over Alaska and the Aleutian Islands and the subpermanent high-pressure area over middle latitudes of the Pacific Ocean as shown by the Honolulu pressures. It will be noted that the pressure at Honolulu was below normal continuously during January and practically all of February, while Alaskan stations report the opposite departures during nearly all of the two months. This is a similar relation to that which exists between the area of low pressure that commonly has its center near and to the west of Iceland and the subpermanent area of high pressure that normally has its center near the Azores. The influence of the general distribution of pressure over the Pacific Ocean and Alaska on determining the types of storms and the tracks followed by them while crossing the United States, and also the character of the highs and the latitudes in which they cross the United States, was referred to in MONTHLY WEATHER REVIEW Supplement No. 1. This statement was to the effect that when the pressure is low over Alaska storms of the United States move in high latitudes and along the Canadian border, but that when the pressure is high over Alaska storms usually strike the Pacific coast south of the Canadian border and follow tracks far south of what otherwise would be the case. Likewise, areas of high pressure enter the United States from Canada when the pressure is high over Alaska, but from the Pacific Ocean when the pressure is low in that region.

In February, 1916, it will be noted that areas of low pressure VI, VIII, IX, and X (Chart III) are of the Alberta type and appeared when the pressure was low over eastern Alaska, as shown by the graphs for Sitka and Eagle (Chart XLIV–21). Other storms during the month either came from the Pacific Ocean in the latitude of Washington and British Columbia or else formed in low latitudes of the United States. All moving high areas during February entered the United States from Canada or formed in the northern Rocky Mountain region, and none entered the United States from the Pacific Ocean.

When there were indications on the 12th that the prolonged period of abnormal cold in the Northwestern

States was about to terminate the following special forecast was issued for distribution to States in that region:

Pressure distribution over Alaska is such as to indicate that the prolonged period of cold weather over the Northwestern States will give way to temperatures above the seasonal average within the next two to three days and moderate temperatures thereafter during the coming week.

WARNINGS IN THE WASHINGTON DISTRICT.

On the 2d storm warnings were ordered from Delaware Breakwater to Boston, the warning reading as follows:

Hoist northeast storm warnings 2 p. m. Delaware Breakwater to Boston. Increasing northeast and east winds with rain and probably snow. Storm over South Carolina will probably move northeast and increase in intensity.

On the morning of the 3d warnings were extended northward to Eastport, Me. The storm under consideration developed on the 2d in the region of counter-flowing winds between two areas of high pressure of great magnitude that had their crests over the southern plains States and in the vicinity of Bermuda. After forming over the South Atlantic States it moved rapidly northeastward in the trough that separated the two areas of high pressure and on the morning of the 3d its center was over Cape Cod and the evening of the same day its center was over Nova Scotia. During its movement northeastward it caused gales on the Middle Atlantic and New England coasts and heavy sleet and snow on the 2d and 3d in the Atlantic States from North Carolina to Maine. On the morning of the 2d the following special forecast was issued to stations in the Middle Atlantic and New England States:

Probably heavy sleet and snow will fall during the next 24 hours in the Middle Atlantic States, southern New England, and West Virginia.

This forecast was wholly verified. At the same time cold-wave warnings were issued for the South Atlantic States, except southern Florida. By the morning of the 3d temperatures had fallen to below the freezing point as far south as north-central Florida.

The next storm of importance in the Washington district formed over the lower Lakes the night of the 6th, and the morning of the 7th, when its center was over the St. Lawrence Valley; storm warnings were ordered on the Atlantic coast from Delaware Breakwater northward to Portland, Me. During the afternoon and night of the 7th the wind blew a gale in the region where warnings were displayed, the maximum velocities reported being as follows: Delaware Breakwater, 64 miles, northwest; Sandy Hook, 56 miles, west; New York, 60 miles, west; Block Island, 60 miles, northwest; Nantucket, 40 miles, northwest; Boston, 36 miles, west; and Portland, 32 miles, west. On the morning of the same day cold-wave warnings were ordered for the Middle Atlantic States and New England, decidedly colder weather following by the morning of the 8th.

From the 8th to 12th no storm of importance prevailed east of the Mississippi River, but during the night of the 12th a disturbance moved from the Mississippi Valley, increased in intensity, and reached the Middle Atlantic States on the morning of the 13th, and, as it gave unmistakable signs of increasing in intensity, warnings of north to northwest gales were ordered at 10 a. m. for the Atlantic coast from Boston to Cape Hatteras, and later in the day storm warnings were ordered south to Jacksonville. Cold-wave warnings were issued the morning of the 13th for the Atlantic States south of Maryland and the east Gulf States. This storm moved off the coast the night of the 13th and northerly gales prevailed as forecast. Decidedly colder weather overspread the Eastern and Southeastern States following the eastward movement of this storm and on the 15th frosts and freezing temperatures occurred as far south as central Florida.

During the night of the 17th, there was a rapid increase in intensity of a storm that was moving eastward from the region of the Great Lakes. On the morning of the 18th, the center of this storm was over Lake Huron and there were indications of a secondary disturbance over the Middle Atlantic States. This type of a cyclonic system has been found to be the precursor of a severe storm on the Atlantic coast and consequently storm warnings were ordered at 10 a. m. of the 18th for the Atlantic coast from Cape Henry, Va., to Eastport, Me., the warning conveying information to the effect that the winds would shift to northerly and westerly and reach gale force during the night of the 18th. The center of the storm passed eastward and at 8 a. m. of the 19th its center was near Eastport, Me., where the barometer read 28.98 inches, and gales were then blowing from the west and northwest on the coast north of Hatteras. The following maximum wind velocities occurred during the 24 hours ended at 8 p. m. of the 19th: Providence, R. I., 59 miles west; Nantucket, 46 miles west; Block Island, 72 miles west; New York, 64 miles northwest; Sandy Hook, 64 miles west; Delaware Breakwater, 64 miles west; Norfolk, 52 miles northwest; and Cape Hatteras, 52 miles northwest. Moreover, on the 18th cold-wave warnings were ordered for the southern portion of the region of the Great Lakes, the Ohio Valley and the Middle Atlantic and New England States. By the morning of the 19th, very much colder weather had overspread these regions.

An area of low pressure that was over the lower Mississippi Valley the 23d was central over South Carolina on the 24th and, as it was of a type that usually moves northeast and increases greatly in intensity, storm warnings were ordered at 9:30 a. m. from Cape Hatteras to Boston, and at 3 p. m. the region of display was extended northward to Eastport, Me. This storm moved northeast as forecast and the morning of the 25th its center was off the Virginia Capes, and winds of gale force were general north of Cape Hatteras. Moreover, the storm winds prevailed off the Middle Atlantic and New England coasts through the 25th, 26th, and 27th, on which days storm warnings remained displayed on some portion of the coast north of Cape Hatteras.

DISTRICT WARNINGS DURING FEBRUARY.

Chicago District.—The month was uneventful as a rule, there being at no time either any sweeping cold waves or heavy snows. The temperature averaged not not far from the normal, being somewhat above in the western and below in the eastern portion of the district. The precipitation was much below the normal throughout the entire district, the lows passing with their centers well to the northward, and usually being dry. Cold-wave warnings for restricted areas were issued on two or three occasions, and these were verified almost without exception. The central office on the morning of February 12, sent a long-range forecast to this station indicating a break in low-temperature conditions in the Northwest and a week of moderate temperature. The advice, which was fully verified, was given wide distribution throughout the northwestern portions of the Chicago district. The forecaster at Chicago had previously predicted a moderation for the Northwest in his general

forecast, and during the early days of the ensuing week predicted a continuation of the mild spell for a considerable period. The long-range forecast was of great service to shippers of perishable goods, railroads, and other transportation companies, and newspapers commented on it favorably.—*H. J. Cox, Professor of Meteorology.*

Denver District.—No cold waves occurred during the month, and no warnings were issued except at the close of the month. At 8 p. m. on the 29th an anticyclonic area of moderate intensity was spreading southward over Montana and cold-wave warnings were issued for eastern Colorado. These warnings were verified by a 24-hour fall in temperature in eastern Colorado of 20° to 30°, and were followed within 36 hours by temperatures ranging from 5°F. to 10°F.—*Frederick W. Brist, Assistant Forecaster.*

New Orleans District.—Cold-wave warnings were issued on the morning of February 12 for Oklahoma and the northwestern portion of east Texas, were extended in the afternoon over the northeastern and southwestern portions of east Texas and northwestern Louisiana, and were extended at night to the Gulf coast. Subsequent conditions justified the warnings. Storm warnings were ordered for the Galveston section on the 12th and storm winds occurred during the display. No general storm occurred during the month. With the exception of the cold wave that passed over the district from the 11th to 13th moderate weather conditions prevailed during the month.—*I. M. Cline, District Forecaster.*

Portland, Oreg., District.—Owing to interruptions in the telegraph and cable services during the month, the making of forecasts was encumbered with difficulties. A sleet storm on the 2d prostrated the wires for 20 miles or more in all directions from Portland and the damage was equally as severe in the neighborhood of Seattle and Tacoma. It was a week or ten days after the storm before the telegraph and telephone companies were able to resume business on a normal basis. Besides the interruption caused by the sleet storm, reports from Alaska were missing for nearly the entire month due to cable trouble, and many reports from the stations in the Aleutian Islands were not received during the first half of the month, which was the time when they were most needed. Storm warnings were issued on the 1st, 5th, 8th, 9th, 13th, and 29th; small-craft warnings on the 7th, 13th, 17th, and 28th. Only one general storm warning was issued, the others being for small areas where the conditions were apparently threatening, and most of these threatening conditions did not develop verifying velocities. The general storm warning was issued on the evening of the 8th to coast stations, and extended the next morning to inland seaports. It was followed by maximum velocities ranging from 36 to 60 miles an hour, and was especially severe on Puget Sound. Live-stock warnings were issued on the 3d, 4th, 5th, 28th, and 29th. Live-stock warnings are a new feature, and those issued on the 3d, 4th, and 5th were to one locality upon special request and in advance of the authorization for the service. They were fully verified and favorably commented on by the recipient. Live-stock warnings were again issued on the 28th to all but four distribution centers, and on the next morning these four centers were notified of expected cold, stormy weather. This warning was fully verified and a newspaper clipping informs us that it was of "much value" to stock raisers. Warnings were issued that the hazard from avalanches would be greatly increased during the period from the 8th to 10th. This class of warnings is also a new departure, and pertained to the increase of the hazard from avalanches. These warnings were issued on the 7th, 8th, and 9th, the first one being an advanced notice of the approach of warmer, windy weather with rain, which is the kind of weather that always causes numerous avalanches when the snow is heavy in the mountains. The subsequent avalanche warnings were for the purpose of calling attention to the fact that the danger period had not yet passed. These warnings were fully justified, judging from newspaper items which contained many notices of slides and avalanches during the period covered by them.—*E. A. Beals, District Forecaster.*

San Francisco District.—There were no storms of a dangerous character nor were there any damaging frosts.—*G. H. Willson, District Forecaster.*

RELATION BETWEEN RAINFALL AND SYNOPTIC WINDS.

H. HELM CLAYTON, In Charge of Forecasting.

[Argentine Meteorological Office, Buenos Ayres. MS. recorded Feb. 24, 1916.]

Rainfall is one of the most important elements, yet it occurs in such irregular, spotted areas as to defy even the most skilled forecaster. For example, on the weather map for May 22, 1913, shown in the accompanying figure figure H. H. C. 1 (XLIV–22), there is an area of rain in the Lake Region and New England, another in the lower Mississippi Valley, and a third on the Pacific coast.

In seeking more definitely the conditions which attend rain, it is well to consider its physical causes. Rain is caused by the chilling of moist air below the point of saturation, so that a part of the moisture falls out. Experience indicates that the most potent if not the only cause of this cooling is the expansion of ascending air as it comes under diminished pressure aloft. The ascent of the air may be induced by: (1) Topography, as for example where air is forced over mountain ranges; (2) heating at the ground, which determines the formation of local ascending currents resulting in cumulus clouds and local showers; (3) converging or opposing winds determined by horizontal differences of temperature and pressure.

The first of these is a climatic factor which a forecaster needs to keep in mind, and the second is the cause of occasional showers, specially in summer, but experience shows that the third is the main cause of our ordinary rainstorms.

When winds are diverging a descent of air is indicated and consequently fair weather, because descending winds are dry. On the contrary, when winds are converging ascending air is indicated and consequently expansion and cooling, resulting in clouds and rain.

The factors determining the intensity of the rainfall are, (1) the angle of convergence, (2) the speed of the wind, (3) the moisture content of the air, and (4) the topography. Coefficients would need to be determined for all these in a proper formula.

The wind is usually indicated on the weather maps to eight points of the compass, and this permits a scale of four steps both for diverging and converging winds, thus (1) ↑ ↗, (2) ↑ →, (3) ↑ ↘, (4) ↑ ↓, for diverging, and a similar scale for converging winds. If on the weather map the diverging winds are marked with red and the converging winds with blue in accordance with the above scale, it becomes apparent that the red marks are located, as a rule, in regions of fair weather and the blue marks in

regions of clouds and rain. See the accompanying chart of May 22, 1913 (fig. 1, XLIV—22).

Studies of this kind render it evident that a condition to be considered in forecasting rainfall is that of converging winds.

In figure 1 the areas of converging winds exceeding 1 on the scale are inclosed with blue lines and the areas of rain are indicated by the symbol R. Since the convergence of the wind on which the rainfall depends is determined by the distribution of pressure, it is possible from a chart showing the anticipated distribution of pressure to forecast both wind and rain.

Plotting wind arrows along the lines of equal pressure according to the relation known to exist in the Northern Hemisphere (not considering speed), the region of converging winds can be easily selected and indicated by shaded areas. In this way the shaded area becomes the predicted area for rainfall.

The method used by me in the Argentine weather service is to predict the pressure distribution for the succeeding day and then draw in the winds and areas of rain. Experience teaches, however, that rain will not result from converging winds in areas where the [relative] humidity is low (60 per cent or less) and the rain area is omitted in such areas. Doubtless such forecasts will increase in accuracy with increasing knowledge and improvement in the method.

Plotting the divergence of the wind in red and the convergence in blue discloses the fact that diverging winds are the usual condition around centers of high pressure and converging winds around centers of low pressure. But this condition is frequently reversed. In the case of reversal there is rain within the area of high pressure where there exist converging winds, and fine weather in the low pressure where there exist diverging winds. Another example of the relation of rainfall to converging winds is shown in the accompanying figure 2 (XLIV—23) for May 3, 1913.

It is not meant to be understood that converging winds are the only factor in rain production. Temperature and humidity are also important factors. It will perhaps be possible to illustrate the effect of temperature distribution at some later date.

The effect of topography appears evident in figure 3 (XLIV—24). Here a broad stream of air is being drawn from the ocean up the gentle slopes of the Appalachian Mountains by a storm of unusual violence and extent, resulting in a long strip of rain along the eastern slope while on the western side of the mountain range where the air is descending the slopes, the sky remains clear notwithstanding the convergence of the wind. On the other hand with a well-defined low pressure over the ocean it frequently clears on the eastern slopes of the mountain while it is still raining or snowing on the western.

LONG-RANGE FORECAST OF THE WINTER MINIMUM TEMPERATURE FOR HAMADA, JAPAN.[1]

By M. ISIDA.

In western Japan there is a well-tried weather proverb current among laymen, to the effect that a severe winter is preceded by an abnormally hot summer.

The author of the paper here abstracted, has for his object the testing of this piece of weather lore by means of the data from instrumental observations, and he has arrived at the striking result that the minimum temperature of the coming winter [at least for the locality studied] can be calculated with great accuracy from the mean temperature of the past summer.

TABLE 1.—*Observed and computed winter minimum temperatures at Hamada, Japan, 1893–1913.*

Year.	Mean summer temperature, T.	Winter minimum temperature.		t_o-t_c.
		Observed t_o.	Calculated t_c.	
	°C.	°C.	°C.	°C.
1893	21.8	−3.7	−3.2	−0.5
1894	23.5	−8.7	−7.7	−1.0
1895	22.1	−4.3	−4.0	−0.3
1896	22.5	−5.3	−5.1	−0.2
1897	21.3	−2.1	−1.8	−0.3
1898	21.9	−3.6	−3.5	−0.1
1899	22.2	−4.2	−4.2	0.0
1900	22.2	−3.2	−4.2	1.0
1901	21.5	−2.0	−2.3	0.3
1902	21.5	−3.2	−1.9	−1.3
1903	22.3	−3.6	−4.5	0.9
1904	21.6	−2.3	−2.6	0.3
1905	22.3	−4.6	−4.6	0.0
1906	21.6	−2.0	−2.6	0.6
1907	21.8	−3.7	−3.2	−0.7
1908	21.8	−2.1	−3.1	−1.0
1909	22.4	−4.6	[1] [−4.8]	[−0.2]
1910	22.0	−3.8	−3.8	0.0
1911	21.3	−2.8	−1.9	−0.9
1912	22.0	−2.9	−3.6	0.7
1913	21.0	−0.9	−1.1	0.2
1914	22.9	.....	.....	.....

[1] Figures in brackets were recomputed.—C. A., jr.

Table 1 gives in its second column the mean air temperature (T) at Hamada, on the west coast of Japan [long. 132¼° E.; lat. 35° N.], for its warm season or about May 11 to September 20. In the 3d, 4th, and 5th columns are given, respectively, the observed minimum temperature, t_o, of the following winter, the calculated minimum temperature, t_c, as obtained by means of the author's equation $t=55.44-2.69\,T$, and the difference t_o-t_c.—*T. O[kada].*

CIRRUS DIRECTIONS AT MELBOURNE AND STORMS AFFECTING VICTORIA.[1]

By E. T. QUAYLE, B. A., Assistant.

[Commonwealth Bureau of Meteorology, Melbourne, Victoria.]

(Abstracted for the REVIEW, by A. J. Henry.)

Systematic observations of the direction of movement of cirrus clouds have been made in Melbourne for many years. The results of these observations for the period 1895 to 1912 have been correlated with the various cyclonic systems which affect the weather of extreme southeastern Australia.

Mr. Quayle groups the cyclones of Australia under eight types, of which by far the greater number belong to the type Antarctic V-depressions. These are first observed as they round Cape Leeuwin, distant from Melbourne about 1,800 miles. Cirrus observations at Melbourne are evidently made with considerable precision and probably by means of a nephoscope. The manner of grouping the data, as explained by the author, was about as follows:

[1] Slightly rearranged and reprinted from the English abstract in Journal of the Meteorological Society of Japan, Feb., 1916, 35, 9-10.

[1] *Quayle, E. T.* Relation between cirrus directions as observed in Melbourne and the approach of the various storm systems affecting Victoria. Melbourne. May, 1915. 1 pl., 40 figs., 27 p. 4°. (Commonwealth Bureau of Meteorology, Bulletin No. 10.)

For each cirrus direction observed at Melbourne there was noted the distance of the barometric trough of the depression or the cyclonic system from Melbourne, the departure from the mean cloud direction for that distance, the daily rate of motion of the trough, the time of its passage over Melbourne, and the intensity of the storm at that place, as indicated by the barometer level.

From the facts thus ascertained a table was prepared, showing the mean cirrus direction over Melbourne for the various distances of the storm trough. These, as the author remarks, varied from month to month in a most interesting fashion. The trough distances varied from 100 to 1,300 miles. The mean direction of cirrus in Australia, as in most other parts of the world where they have been systematically observed, is from west to east. The author found it convenient to call true west zero; that is, a movement from west to east was entered as zero when the direction was from true west. When the deviation from true west was to the north, it was recorded as plus (+) so many degrees, and when to the south it was recorded minus (−) so many degrees.

The most northerly average cirrus direction for any trough distance was in August, when for troughs distant from Melbourne 1,000 miles it was slightly north of west, +1°; at a trough distance of 500 miles for the same month the deviation was +23°, or west 23° north, and for trough distance of but 100 miles the deviation was west 41° north. The extreme southerly deviation for trough distance of 1,000 miles was −27° in December; for trough distance 500 miles west 3° south, in the same month, and for all trough distances less than 400 miles the deviation is always to the north, and generally from 25° to 30°. The seasonal shift of the upper currents thus brought out is a phenomenon of world-wide distribution but the apparent control of cirrus direction by cyclonic circulations has not been observed in the United States, so far as the writer is aware.

A casual inspection of the synoptic cloud charts of the United States Weather Bureau extending over a number of years leaves the impression that the direction of cirrus clouds in the United States is practically independent of either cyclonic or anticyclonic circulations. It is probable that the cloud directions as recorded in the daily observations of the Weather Bureau, viz, to the eight principal points of the compass only, are not sufficiently precise to show the deviations observed in Australia. Precise observations of cloud directions made at Blue Hill Observatory [2] show that the mean direction of the cirrus is different for cyclones which advance from different directions, and that in general the cirrus tends to move in the same direction as the accompanying cyclones and anticyclones move. The movement of the cirrus is, however, on the average, from a slightly more westerly direction than that of the accompanying cyclone or anticyclone.

The following are some instances of the significance of cloud movements in weather forecasting as given by Mr. Quayle:

(1) If the first cirrus observed when a storm is approaching is from the SSW or SW, little rain may be expected.

(2) If, however, it veers rapidly northward as the storm approaches, and, especially if in the case of an "Antarctic" low, for any given distance of the trough the direction of movement reaches a point more northerly than the average for that distance, good general rains may be expected.

(3) If, in addition to (2), the trough is moving slowly, the storm is likely to prove cyclonic round a center passing either over Tasmania, Bass Strait, or inland Victoria. The more northerly the track of the center the better the rainfall, as a rule.

(4) Cirrus movements beginning well, but failing to maintain their northward backing or tending to disappear, suggest either the destruction of the storm, or its deflection into the far interior of the continent, or possibly its slipping southward from the Bight. If passing northeastward from the Bight into New South Wales or Queensland, cirrostratus is usually visible low down in the northwestern horizon and lying parallel to it.

(5) Movement persisting from some northerly point in spite of locally fine weather is a very reliable sign of rain, especially over the interiors of New South Wales and Victoria.

(6) Cirrus tending easterly through north indicates the storm center to be passing eastward north of the observer, while directions between E and SSE generally go with an active storm center off the New South Wales south coast line, with much rain there and in East Gippsland, and high pressure over Tasmania or southwestern Victoria.

(7) Cirrus coming from the south (SSE–SSW) may have no apparent relation to storm systems, and is often seen in purely anticyclonic weather. It is also seen occasionally as the result of storm energy when the center of a vigorous cyclone is passing over or not far south of Melbourne, or has formed somewhere off Gabo Island. But, whatever its relationship, cirrus from this direction indicates conditions very unfavorable to the development or eastward progress of Antarctic disturbances approaching from the west.

[2] *Clayton* in Annals of the Astronomical Observatory, Harvard College, vol. 30, Part IV.

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, FEBRUARY, 1916.

By ALFRED J. HENRY, Professor in Charge of River and Flood Division.

[Dated: Washington, D. C., Mar. 27, 1916.]

At the close of January, 1916, the Mississippi and the lower Ohio Rivers were at flood stages. The Mississippi at Cairo, Ill., passed below flood stage on February 17; at Memphis, Tenn., on February 23; at Helena, Ark., on March 1. At points below Helena the river was above flood stage the entire month of February. The Atchafalaya in Louisiana, the Yazoo in Mississippi ,and the Illinois at La Salle and Beardstown were also above the flood stage the entire month. At the close of the month the flood in the lower Mississippi was receding rapidly and there was every indication that no more agricultural land would be overflowed. The overflowed land during February and March, 1916, in the New Orleans river district amounted to about 285 square miles. The overflowed area in Mississippi and Arkansas has not yet been determined.

PROPERTY LOSS BY THE FLOODS OF JANUARY–FEBRUARY, 1916.

East of the Rocky Mountains.

Live stock and other movable farm property	$134,682.00
Suspension of business and loss of wages	186,962.00
Matured crops	88,600.00
Prospective crops	229,350.00
Tangible property, houses, bridges, etc	657,820.00
Loss to railroads, roadbeds, equipment, etc	1,014,772.00
Total	2,312,186.00

West of Rocky Mountains, southern California and Arizona.

Agricultural lands, washed away (Arizona)	$120,000.00
Irrigation works damaged and destroyed (Arizona)	101,000.00
Highways and bridges, excluding railway bridges	1,154,500.00
Agricultural lands, erosion or inundation	1,516,000.00
Irrigation works, including reservoirs, conduits, etc	2,000,000.00
Miscellaneous losses, excluding damage to railroads, telegraph and telephone companies	400,000.00
Total	5,291,500.00
Grand total	7,603,686.00
Estimated saving by warnings east of Rocky Mountains	1,208,140.00

About the usual number of flood stages occurred during the month in the various rivers, as shown by Tables 1 to 6, inclusive. The majority of these were of short duration and more or less local, except that the flood in the Willamette River of Oregon was quite general throughout the course of the stream. Tables 1 to 6 follow.

TABLE 1.—*Flood stages in the Red River and the rivers of Louisiana and Texas, February, 1916.*

River.	Station.	Flood stage.	Above flood stage. From—	Above flood stage. To—	Crest stage.	Date.
		Feet.			*Feet.*	
Red	Spring Bank, Ark	29.0	4	12	31.4	7
Do	Fulton, Ark	28.0	[1] 29	4	32.2	4
Do	Alexandria, La	36.0	13	20	36.8	16, 17
Do	Grand Ecore, La	30.0	5	19	35.7	12, 13
Sulphur	Finley, Tex	24.0	[1] 30	7	27.0	3
Little	Whitecliffs, Ark	28.0	3	3	28.4	3
Ouachita	Monroe, La	40.0	15	25	40.6	19, 20
Atchafalaya	Simmesport, La	41.0	3	([2])	48.5	[3] 1–6
Sabine	Logansport, La	25.0	1	6	26.4	3
Trinity	Long Lake, Tex	40.0	8	13	40.8	9
Do	Liberty, Tex	25.0	22	23	25.0	22, 23
Do	Trinidad, Tex	28.0	[1] 30	11	37.5	5

[1] January. [2] 41.3 feet on Mar. 29, 1916. [3] March.

TABLE 2.—*Flood stages in the rivers of the East Gulf and South Atlantic States, February, 1916.*

River.	Station.	Flood stage.	Above flood stage. From—	Above flood stage. To—	Crest stage.	Date.
		Feet.			*Feet.*	
Dan	Danville, Va	8.0	3	3	8.6	3
Do	Clarksville, Va	12.0	4	4	11.3	4
Roanoke	Weldon, N. C	30.0	3	6	39.7	5
Neuse	Neuse, N. C	12.0	3	7	18.4	5
Do	Smithfield, N. C	13.0	4	9	17.1	8
Cape Fear	Fayetteville, N. C	35.0	4	6	44.5	4
Do	Elizabethtown, N. C	20.0	4	8	30.2	6
Haw	Moncure, N. C	22.0	3	3	26.7	3
Saluda	Pelzer, S. C	7.0	2	3	8.6	2
Do	Chappels, S. C	14.0	3	5	20.3	4
Pee Dee	Cheraw, S. C	27.0	3	6	36.3	4
Do	Smiths Mills, S. C	14.0	10	17	16.8	12
Santee	Rimini, S. C	12.0	3	15	21.5	7
Do	Ferguson, S. C	12.0	5	18	15.7	9
Wateree	Camden, S. C	24.0	3	5	34.4	3
Catawba	Catawba, S. C	11.0	2	4	21.2	3
Congaree	Columbia, S. C	15.0	3	5	22.7	4
Broad (in South Carolina).	Blairs, S. C	14.0	3	4	20.9	3
Broad (in Georgia)	Carlton, Ga	11.0	2	2	12.4	2
Alabama	Selma, Ala	35.0	5	6	36.2	6

TABLE 3.—*Flood stages in the rivers of the Great Lakes drainage, in the Des Moines, and in the Connecticut, February, 1916.*

River.	Station.	Flood stage.	Above flood stage. From—	Above flood stage. To—	Crest stage.	Date.
		Feet.			*Feet.*	
Connecticut	Hartford, Conn	16.0	28	29	17.7	28
St. Joseph	Montpelier, Ohio	10.0	[1] 31	2	12.8	1
Sandusky	Tiffin, Ohio	10.0	1	2	10.3	1
Auglaize	Defiance, Ohio	10.0	1	2	11.5	2
Maumee	Napoleon, Ohio	10.0	1	2	11.7	2
Do	Fort Wayne, Ind	15.0	[1] 31	4	20.2	1
Grand	East Lansing, Mich	7.5	1	1	7.6	1
Do	Grand Rapids, Mich	11.0	5	11	15.3	7
Des Moines	Boone, Iowa	11.5	22	24	13.9	23

[1] January.

TABLE 4.—*Flood stages in the rivers of the Pacific slope, February, 1916.*

River.	Station.	Flood stage.	Above flood stage. From—	Above flood stage. To—	Crest stage.	Date.
		Feet.			*Feet.*	
Columbia	Vancouver, Wash.	15.0	12	13	15.7	12
Willamette	Eugene, Oreg.	10.0	7	9	18.2	7
Do	Albany, Oreg.	20.0	8	10	28.0	8
Do	Salem, Oreg.	20.0	8	10	26.2	9
Do	Oregon City, Oreg.	12.0	8	14	15.0	10
Do	Portland, Oreg.	15.0	9	14	20.0	11
Santiam	Jefferson, Oreg.	10.0	7	8	14.9	7
Yamhill	McMinnville, Oreg.	35.0	10	12	39.1	11
Clackamas	Cazadero, Oreg.	8.0	7	8	11.9	7
Sacramento	Red Bluff, Cal.	23.0	10	11	24.0	10
San Joaquin	Lathrop, Cal.	17.0	7	7	17.0	7

TABLE 5.—*Flood stages in the tributaries of the Ohio, February, 1916.*

River.	Station.	Flood stage.	Above flood stage. From—	Above flood stage. To—	Crest stage.	Date.
		Feet.			*Feet.*	
French Broad	Asheville	4.0	3	3	4.0	3
Tennessee	Knoxville, Tenn.	12.0	3	4	14.0	3
Monongahela	Fairmont, W. Va.	25.0	13	13	25.0	13
Do	Greensboro, Pa.	20.0	13	13	23.0	13
Do	Lock No. 4, Pa.	31.0	14	14	31.7	14
Little Kanawha	Glenville, W. Va.	22.0	13	13	22.5	13
Do	Creston, W. Va.	20.0	13	13	20.6	13
Walhonding	Walhonding, Ohio	8.0	1	1	8.0	1
Scioto	Prospect, Ohio	10.0	1	2	10.9	2
Do	Circleville, Ohio	7.0	1	3	11.1	1
Miami	Tadmor, Ohio	12.0	[1] 31	1	14.8	1
Wabash	Bluffton, Ind.	12.0	1	2	13.5	1
Do	Logansport, Ind.	12.0	[1] 31	2	14.6	1
Do	La Fayette, Ind.	11.0	[1] 29	5	23.5	2
Do	Terre Haute, Ind.	16.0	[1] 31	8	23.0	2
Do	Mount Carmel, Ill.	15.0	[1] 1	17	26.7	7

[1] January.

TABLE 6.—*Flood stages in the Missouri River and tributaries, February, 1916.*

River.	Station.	Flood stage.	Above flood stage. From—	Above flood stage. To—	Crest stage.	Date.
		Feet.			*Feet.*	
Missouri	Blair, Nebr.	15.0	26	29	16.6	27
Blue	Beatrice, Nebr.	16.0	18	18	18.0	18
Grand	Chillicothe, Mo.	18.0	20	22	19.8	21
Osage	Bagnell, Mo.	28.0	[1] 28	4	32.8	1

[1] January.

Hydrographs for typical points on several principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

SNOWFALL AT HIGH ALTITUDES, FEBRUARY, 1916.

An exceptionally heavy snow cover in the mountains accumulated during January, 1916. A severe snowstorm during the first few days of February, 1916, added a considerable amount in Oregon, Washington, Idaho, and in Montana, west of the Continental Divide. Subsequent weather, however, was not favorable to the conservation of the snow and by the close of the month much snow had disappeared from the lower levels up to 7,000 feet and on the south slopes. The remaining snow was well packed, and the outlook for irrigation and power water, though not so bright as at the close of the preceding month, was still favorable in practically all localities.—A. J. H.

RELATION OF PRECIPITATION TO STREAM FLOW IN MONTANA.

By R. FRANK YOUNG, Meteorologist.

[Dated: Weather Bureau, Dayton, Ohio, Feb. 14, 1916.]

The region under discussion in this paper is that portion of the northern Rocky Mountains which forms the headwaters basin of the Missouri-Mississippi drainage. It is outlined in figure 1, below.

FIGURE 1.—Sketch map of the headwaters of the Missouri in Montana.

Investigations of the water resources in the Rocky Mountains have generally proceeded on the assumption that the most important, if not the only important influence controlling the summer flow of streams is the amount of snow accumulated in the mountains at the close of the snow season. The facts here presented seem to warrant the statement that the question is one of somewhat greater complexity than this view recognizes; but fortunately the greater complexity of the problem does not necessarily add to the difficulty of its solution. The great amount of labor involved in the measurement of the depth of snow over large areas, and the unavoidable inaccuracy of measurements of drifted snow, which may vary in depth from a few inches to 50 feet or more, would probably render this method impracticable for the northern Rocky Mountain region as a whole. Fuller investigation may show that more reliable estimates of the amount of moisture stored in the mountains can be made from careful and well distributed records of precipitation and temperature, supplemented by evaporation measurements, than from any number of measurements of snow on the ground. This applies particularly to the eastern slope of the northern Rockies where the snow, as a rule, is nearly all blown into drifts, and where under normal temperature conditions there is practically no loss except by evaporation during the winter months.

TABLE 1.—*Average monthly departure from normal of stream flow at Canyon Ferry, Mont, and of precipitation and temperature over the watershed above Canyon Ferry.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.												
Streamflow (cu. ft./sec.)	− 110	− 770	−1,630	−1,690	−2,180	− 3,710	−1,560	− 940	− 870	−1,100	− 800	+ 230
Precipitation (in.)	−0.13	− 0.38	+ 0.06	+ 1.30	− 1.09	− 0.60	+ 1.17	− 0.48	− 0.52	− 0.58	+ 0.58	+0.09
Temperature (°F.)	+ 4.6	− 3.2	− 1.0	− 1.0	− 3.3	+ 1.8	− 2.8	+ 0.4	− 2.4	+ 3.8	− 3.2	+ 1.0
1904.												
Stream flow (cu. ft./sec.)	+ 90	− 270	− 430	+ 10	+1,020	− 2,210	−1,560	− 940	− 570	− 800	− 800	− 270
Precipitation (in.)	−0.13	+ 1.11	+ 0.70	− 0.77	− 1.50	− 0.87	− 0.13	− 0.37	− 1.27	− 0.68	− 0.64	+0.11
Temperature (°F.)	+ 4.3	+ 1.0	− 1.5	+ 3.9	− 0.2	− 1.8	− 1.0	+ 0.4	+ 0.8	+ 4.0	+ 6.6	+ 2.7
1905.												
Stream flow (cu. ft./sec.)	+ 90	− 670	− 330	−1,690	−5,180	− 7,710	−2,060	−1,440	−1,870	−1,700	−1,100	− 370
Precipitation (in)	−0.41	− 0.40	− 0.04	− 0.24	− 0.41	+ 0.30	− 0.12	− 0.01	− 0.45	− 0.56	− 0.09	−0.35
Temperature (°F.)	+ 2.2	− 4.9	+ 6.4	+ 1.7	− 3.0	− 3.6	+ 0.4	− 1.2	+ 3.1	− 4.6	− 0.1	− 1.6
1906.												
Stream flow (cu. ft./sec.)	− 610	− 370	− 830	− 990	−1,680	− 5,710	−2,560	−2,060	+ 130	−1,000	− 900	+ 530
Precipitation (in.)	+0.01	+ 0.09	− 0.21	− 0.22	+ 0.50	+ 0.06	− 0.85	+ 1.18	− 0.54	− 0.58	+ 0.10	+0.22
Temperature (°F.)	+ 4.3	+ 5.5	− 6.0	+ 4.0	− 0.7	− 4.3	+ 2.1	− 0.8	+ 1.2	+ 3.0	− 2.3	+ 5.5
1907.												
Stream flow (cu. ft./sec.)	− 210	+ 830	+ 770	+ 910	+ 320	+ 3,290	+9,940	+2,060	+ 130	− 300	− 500	− 270
Precipitation (in.)	−0.21	+ 0.26	+ 0.58	− 0.46	− 0.75	+ 1.21	+ 0.88	+ 0.40	− 0.44	− 0.42	− 0.49	−0.14
Temperature (°F.)	− 8.8	+ 7.0	+ 3.8	− 0.9	− 2.0	− 4.5	− 1.7	− 3.2	− 0.1	+ 5.5	+ 3.2	+ 2.1
1908.												
Stream flow (cu. ft./sec.)	− 110	− 370	− 230	+ 510	−1,180	+11,290	+3,440	+ 60	+ 630	+1,300	+ 700	+ 530
Precipitation (in.)	−0.30	+ 0.07	+ 0.32	− 0.53	+ 4.17	+ 1.62	− 0.62	− 0.11	+ 0.01	+ 0.52	− 0.52	−0.40
Temperature (°F.)	+ 3.8	+ 3.3	+ 2.7	+ 4.1	− 1.7	− 4.5	+ 2.3	− 1.1	+ 2.2	− 1.4	+ 1.4	+ 0.1
1909.												
Stream flow (cu. ft./sec.)	+ 590	+ 530	+ 70	− 490	− 880	+ 3,290	− 60	− 440	+1,630	+ 700	+ 700	+ 30
Precipitation (in.)	+0.30	− 0.27	+ 0.59	− 0.08	+ 0.03	− 0.88	+ 1.28	− 0.02	+ 2.30	− 0.41	+ 0.95	+0.11
Temperature (°F.)	− 1.5	+ 3.5	+ 1.5	− 5.0	− 3.3	+ 0.2	− 0.1	+ 1.1	+ 1.4	+ 1.3	+ 1.8	− 2.0
1910.												
Stream flow (cu. ft./sec.)	+ 90	+ 130	+2,870	+2,510	+3,320	− 7,710	−4,560	−1,840	− 870	− 600	− 300	− 70
Precipitation (in.)	+0.26	+ 0.06	− 0.56	− 0.15	− 0.34	− 0.96	− 0.40	− 0.19	+ 1.03	+ 0.39	+ 0.64	−0.36
Temperature (°F.)	− 3.2	− 5.1	+ 9.9	+ 5.8	+ 1.7	+ 2.2	+ 2.9	− 1.7	− 0.9	+ 2.7	+ 1.4	+ 1.2
1911.												
Stream flow (cu. ft./sec.)	− 210	− 370	+ 70	−1,690	−1,980	+ 3,290	−1,060	− 440	− 370	− 300	− 500	− 470
Precipitation (in.)	+0.34	− 0.16	− 0.74	− 0.34	− 0.17	+ 1.01	− 0.69	+ 0.05	+ 0.01	+ 0.78	+ 0.07	+0.03
Temperature (°F.)	+ 2.0	− 3.5	+ 5.8	− 1.2	− 2.1	+ 0.9	− 2.0	− 3.3	− 2.7	− 2.5	− 5.9	− 2.3
1912.												
Stream flow (cu. ft./sec.)	+ 90	+ 430	− 930	− 390	+2,820	+ 5,290	+ 440	+1,560	+1,430	+1,400	+1,200	+ 530
Precipitation (in.)	−0.40	− 0.34	+ 0.21	+ 0.52	− 0.29	− 0.77	+ 0.12	+ 0.92	+ 0.05	+ 0.70	− 0.35	−0.20
Temperature (°F.)	+ 2.8	+ 3.2	− 9.4	+ 0.3	− 1.4	+ 1.4	− 3.2	− 3.2	− 6.1	− 2.9	+ 4.2	− 1.9
1913.												
Stream flow (cu. ft./sec.)	− 410	− 570	− 930	+2,010	+2,820	+ 6,290	+1,440	+ 560	− 370	+ 800	+1,100	− 170
Precipitation (in.)	−0.18	− 0.13	− 0.04	− 0.11	− 0.65	+ 2.50	+ 0.70	− 0.19	− 0.27	+ 0.56	+ 0.12	−0.50
Temperature (°F.)	+ 0.9	− 6.5	− 3.7	+ 0.9	− 0.4	+ 0.2	− 2.5	+ 1.4	− 0.1	− 3.3	+ 1.8	− 2.1
1914.												
Stream flow (cu. ft./sec.)	+ 580	+ 710	+ 310	+ 290	+3,420	− 2,010	−2,580	−1,325	− 540	+1,160	+ 620	− 180
Precipitation (in.)	−0.14	+ 0.06	− 0.62	+ 0.35	− 0.55	+ 1.01	− 0.14	− 0.95	+ 0.54	+ 0.56	− 0.58	−0.40
Temperature (°F.)	+ 8.3	+ 2.0	+ 4.6	+ 1.8	+ 0.1	− 1.9	+ 1.8	− 1.4	− 0.8	+ 1.8	+ 5.7	− 4.2
1915.												
Stream flow (cu. ft./sec.)	+ 130	+1,940	+1,220	+ 740	− 660	− 3,730	+ 680	+1,190	+1,480	+ 560	+ 520	+ 850
Precipitation (in.)	−0.10	− 0.22	+ 0.09	+ 0.06	+ 0.56	+ 1.56	+ 1.51	+ 0.02	+ 0.85	− 0.71	+ 0.12	.....
Temperature (°F.)	+ 2.2	+ 7.6	+ 4.5	+ 7.8	− 1.6	− 5.7	− 4.6	+ 2.4	− 3.8	+ 4.0	− 0.8	.....
Normal temperature and precipitation for the watershed above Canyon Ferry:												
Temperature (° F.)	19.2	21.1	29.0	39.8	49.2	57.2	62.8	61.8	52.9	41.9	31.3	22.2
Precipitation (in.)	0.79	0.61	0.99	1.09	2.64	2.28	1.31	1.01	1.39	1.15	0.74	0.70

TABLE 2.—*Average discharge of the Missouri River at Canyon Ferry, Mont.*

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	Cu. ft./sec.	*Cu. ft./sec.*	*Cu. ft./sec.*	*Cu. ft./sec.*	*Cu. ft./sec.*	*Cu. ft./sec.*	*Cu. ft./sec.*	*Cu. ft./sec.*	*Cu. ft./sec.*	*Cu. ft./sec.*	*Cu. ft./sec.*	*Cu. ft./sec.*
1903	2,800	2,600	2,800	4,300	7,000	11,000	5,000	2,500	2,500	3,000	3,300	3,500
1904	3,000	3,100	4,000	6,000	10,200	12,500	5,000	2,500	2,800	3,300	3,300	3,000
1905	3,000	2,700	4,100	4,300	4,000	7,000	4,500	2,000	1,500	2,400	3,000	2,900
1906	2,300	3,000	3,600	5,000	7,500	9,000	4,000	5,500	3,500	3,100	3,200	3,800
1907	2,700	4,200	5,200	6,900	9,500	18,000	16,500	5,500	3,500	3,800	3,600	3,000
1908	2,800	3,000	4,200	6,500	8,000	26,000	10,000	3,500	4,000	5,400	4,800	3,800
1909	3,500	3,900	4,500	5,500	8,300	18,000	6,500	3,000	5,000	4,800	4,800	3,300
1910	3,000	3,500	7,300	8,500	12,500	7,000	2,000	1,600	2,500	3,500	3,800	3,200
1911	2,700	3,000	4,500	4,300	7,200	18,000	5,500	3,000	3,000	3,800	3,600	2,800
1912	3,000	3,800	3,500	5,600	12,000	20,000	7,000	5,000	4,800	5,500	5,300	3,800
1913	2,500	2,800	3,500	8,000	12,000	21,000	8,000	4,000	3,000	4,900	5,200	3,100
1914	3,490	4,080	4,740	6,280	12,600	12,700	3,980	2,120	2,830	5,160	4,720	3,090
1915	3,040	5,310	5,660	6,730	8,520	10,980	7,240	4,630	4,850	4,660	4,620	4,120

Perhaps the most striking facts disclosed by this correlation of data on stream flow and precipitation are: (1) An excess of snow in the mountains at the close of the snow season does not give assurance of a normal stream flow during the following summer; (2) neither a heavy winter snowfall nor a large accumulation of snow in the mountains in spring is essential to a normal summer stream flow.

There are several instances in which the data of Table 1 support these statements, but two of the most striking will serve to illustrate the points. The autumn and winter of 1909–10 were unusually favorable for the storage of moisture in the form of snow in the mountains of the upper Missouri watershed, and at the close of February, 1910, all available information showed a marked excess in the stock of snow. Nevertheless while careful measurements by the Montana Power Co. showed the stream flow at Canyon Ferry from March to May, inclusive, was decidedly in excess of the normal, there was a yet more marked deficiency from June to August. In this case there is a very plausible explanation in the fact that both March and April, 1910, were abnormally warm and dry, and before the middle of the latter month all snow in the mountains except scattered drifts, which were of little consequence, had disappeared. The loss during these months, both by run-off and evaporation was excessive, and there was no excess in precipitation during May and June to offset this loss.

In 1914–15 practically the reverse of these conditions obtained. There was a marked deficiency in the late autumn and winter precipitation and less snow in the mountains at the close of winter than for many years. There were, however, similar temperature conditions in March and April, which were much warmer than normal in 1915 as in 1910. This of course tended to accentuate the shortage of snow. Apparently the only effect of this very unusual lack of snow was a marked deficiency in water during the flood stages of May and June.

The explanation of this is of general application to the northern Rocky Mountains, especially the eastern slope. In discussing the abnormal conditions existing at that time the following comment was made in the Montana snow bulletin for March, 1915:

> While the winter snowfall is important as a rule in its effect on the summer stream flow, it is not always, and perhaps not as a rule the controlling factor in the supply during the low water period of July, August, and September. An excess of snow in the mountains is reflected to a greater extent in the May and June flood stages than in the low-water stages in July and August. After a winter of normal or excessive snow accumulation, the snow from the foothills and southern slopes disappears during March and April. The effect of the water from the snow that melts during this early period, upon the late flow of the streams will depend on the condition of the ground at the time of melting. If the ground beneath the snow is frozen to a considerable depth, only a small percentage of the water will seep into the soil, to appear later as ground water. As the season advances the melting gradually extends to higher altitudes and to the north slopes, and the maximum run-off is reached late in May or early in June, when the effect of the comparatively heavy rains of these months is combined with that of the melting snow. During these months the ground is fairly well saturated, and normally there is sufficient moisture for agricultural purposes without irrigation, and this surplus water in the streams is not utilized except in a few instances to fill storage reservoirs.
>
> Following a winter of deficient snowfall the entire surface of the ground at lower altitudes becomes free from frost and comparatively dry by the middle of April, and is in condition to absorb the maximum amount of moisture during the wet season, comprising May and June. The water thus absorbed, to a large extent, reaches the streams at a later period when most needed to offset the deficiency from winter snow.

In the final paragraph of the bulletin it was stated that—

> The foregoing facts seem to forecast without reasonable doubt that the flow in all streams during the period of high water in May and June, 1915, will be far below normal; but with an excess, or even normal, May and June rains to replenish the ground sources of water supply, the late flow will not likely show a corresponding deficiency.

As was clearly anticipated in this statement, the May and June stream flow was deficient, although May was moderately wet and June and July were excessively so. The excess in stream flow began with July and the percentage of excess increased through August and September; the October and November flow was much above normal notwithstanding that the precipitation was only slightly above normal after July.

SUMMARY.

While the data at present available may not be conclusive on all points, it is believed that the following facts are more or less clearly brought out:

The main supply for the streams during most of the year is ground water. The only conditions under which surface run-off has a marked effect are (1) an abnormally warm March and April, following a winter of heavy snow, or (2) excessive May and June rains coming while there is still much unmelted snow in the mountains.

A uniform snow cover over the entire watershed would better serve to replenish the ground sources than the same amount accumulated in drifts; so that a forested area, by preventing drifting as well as rapid melting and evaporation, is a better conserver of the water supply than is an open country.

The condition of the ground beneath the snow, whether frozen or free from frost, is an important factor in run-off control.

The slight fluctuation in winter stream flow lends support to the inference that under normal conditions there is no material loss by run-off during this season, and that therefore the amount of water stored in the mountains at the close of winter is approximately what falls from November to February, inclusive, minus the loss by evaporation.

MEAN LAKE LEVELS DURING FEBRUARY, 1916.

By UNITED STATES LAKE SURVEY

[Dated: Detroit, Mich., Mar. 3, 1916.]

The following data are reported in the Notice to Mariners of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during February, 1916:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea-level at New York	602.44	579.47	571.99	245.41
Above or below—				
Mean stage of January, 1916	−0.15	+0.25	+0.31	+0.36
Mean stage of February, 1915	+0.75	−0.09	+0.63	+0.42
Average stage for February, last 10 years	+0.70	−0.53	+0.31	−0.31
Highest recorded February stage	−0.04	−3.25	−1.76	−2.26
Lowest recorded February stage	+1.68	+0.30	+1.36	+2.42
Average relation of the February level to:				
January level	−0.2	0.0	−0.1	+0.2
March level	+0.2	0.0	−0.1	−0.2

ERRATA.

Please make the following changes in the statistics for the floods as published in this REVIEW for January, 1916:

Page 30. Column 1, next to last line, *for* "Greenville, 57.3 feet" *read* "Greenville, 50.6 feet."

Page 30. Column 1, last line, change to read "was overstopped by 0.1 foot."

Page 31. Table 2, Crest stage at Newport, Ark., *for* "33.4 feet" *read* "34.3 feet."

Page 32. Table 6, last line, *for* "Jan. 17, stage 51.8 feet" *read* "Feb. 17, stage 53.4 feet."

Page 33. Table 9, Crest stage at Melville, La., *for* "41.9 feet on Mar. 1–4" *read* "43.2 feet on Feb. 14."

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR FEBRUARY, 1916.

By W. J. HUMPHREYS, Professor in charge of Seismological Investigations.

[Dated: Weather Bureau, Washington, D. C., Apr. 3, 1916.]

TABLE 1.—*Noninstrumental earthquake reports, February, 1916.*

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
1916.		ALABAMA.								
Feb.	*H. m.*		° ′	° ′			*Secs.*			
21	23 40	Anniston	33 39	85 50	2	1	30			U.S. Weather Bureau.
	23 40	Valley Head	34 32	85 32	2	3	14		Windows rattled	Dr. M. T. Floyd.
		CALIFORNIA.								
2	6 30	Julian	33 05	116 37	2	1	4	Rumbling		J. H. L. Vogt.
4	20 30	Hollister	36 50	121 20	4–5	1				J. N. Thompson.
19	15 05	Bridgeport	38 18	119 15	3	2	40			A. F. Scott.
25	23 30	Cahuilla	33 32	116 43	4	1		Rumbling	Shook buildings	Wm. L. Shawk.
	23 30	Nellie	33 22	116 52	3	1				Esther Hewlett.
27	13 26	Los Alamos	34 45	120 15		1				J. W. Robbins.
		GEORGIA.								
21	23 40	Atlanta	33 45	84 23	4	1			Shook buildings	(Press report.)
	23 40	Augusta	33 28	81 54	4	3			Shook dishes from shelves	U.S. Weather Bureau.
	23 40	Canton	34 14	84 29	3–4	2				Mrs. Ada Mills.
	23 40	Clarksville	34 36	83 30	2	2			Windows rattled	Garnett McMillian.
	23 40	Clayton	34 35	83 23	4–5	1				W. R. Cannon.
	23 40	Columbus	32 28	85 00	3	2	15			A. J. Land.
	23 40	Dahlonega	34 32	83 59	4	1		Rumbling	Dishes rattled	Prof. B. P. Gaillard.
	23 40	Duluth	34 00	84 08	4	1				W. O. Medlock.
	23 40	Gillsville	34 18	83 38	4	1	15			G. W. Lichtenstine.
	23 40	Kirkwood	33 46	84 18	3	1	2			A. B. Nichols.
	23 40	Macon	32 50	83 38	3		20			U. S. Weather Bureau.
	23 40	Savannah	32 05	81 05	1	2	Few.			U. S. Weather Bureau.
	23 40	Toccoa	34 34	83 19	4	1	30	Rumbling		Miss Marian Craig.
	23 40	Washington	33 41	82 46	3	2	6	Rattling		W. H. Barnett.
		ILLINOIS.								
18	1 27	New Burnside	37 36	88 46	3	1	1			Miss May McCabe.
		KENTUCKY.								
21	23 40	Middlesboro	36 36	83 43	4	1	10	Rumbling	Shook buildings	B. W. Perkins.
		NEVADA.								
3	5 00	Amos	41 26	117 48	4	1	8			F. M. Payne.
	5 00	Elko	40 51	115 45						G. M. Blair.
	5 00	Eureka	39 23	115 59		1	1			Clay Simms.
	5 00	Fallon	39 30	118 48	3	1	5			F. B. Headley.
	5 00	Geriach	40 38	119 24	6	1	30			W. Pacific Ry.
	5 00	Rebel Creek	41 39	117 45	4–5	2	6			F. W. Whitaker.
	5 00	Tuscarora	41 18	116 13		1				J. C. Butler.
	5 00	Winnemucca	40 58	117 43	4	1	30			U. S. Weather Bureau.
14	6 00	Paradise Valley	41 32	117 34	6	1	1		Bells rung	R. M. Taylor.
		NEW YORK.								
4	4 26	Albany	42 39	73 45	4			Rumbling		U. S. Weather Bureau.
	4 26	Amsterdam	42 55	74 08	4–5	2		do	Shook buildings	Robt. M. Hartley.
	4 26	Ballston Lake	42 53	73 52	4–5	2		do	Awakened many	E. I. Schauber.
	4 26	Clifton Park	42 52	73 46	2					Martin Sharp.
	4 26	Gloversville	43 04	74 20			Few.	Rumbling		W. L. McLean.
	4 26	Glenn Falls	43 21	73 36				do		C. L. Williams.
	4 26	Greenfield Center	43 09	73 50	4	1	30	do	Windows rattled	S. E. Darrow.
	4 26	Little Falls	43 05	74 51	3	2				G. H. Phillips.
		NORTH CAROLINA.								
21	23 40	Alta Pass	35 53	82 00	3–4	1	10		Some alarm	J. S. Bowen.
	23 40	Andrews	35 11	83 48		1		Rumbling		A. V. Calhoun.
	23 40	Asheville	35 36	82 32	5	2	10	Rattling	Caused some alarm	U. S. Weather Bureau.
	23 40	Black Mountain	35 41	82 24	5	2	30	Rumbling		W. C. Hall.
	23 40	Blantyre	35 16	82 36	4	1	10	do	Doors moved	J. E. Davidson.
	23 40	Brevard	35 12	82 45	5	2		do		C. H. Trowbridge.
	23 40	Brewers	36 22	81 06	3	3	45	Faint		W. L. Brewer.
	23 40	Caroleen	35 15	81 50	4			Rumbling		S. B. Tanner.
	23 40	Charlotte	35 13	80 51	7	1	60			U. S. Weather Bureau.
	23 40	Chimney Rock	35 26	82 14	5	1	4			J. M. Flack.
	23 40	Cullowhee	35 18	83 10	3	1	60	Rumbling		F. H. Brown.
	23 40	Elizabethton	34 35	78 33		1				H. H. Barnhill.
	23 40	Elkin	36 14	80 51	4	1			Shook buildings	C. L. Myers.
	23 40	Franklin	35 10	83 22						F. L. Smith.

TABLE 1.—*Noninstrumental earthquake reports, February, 1916*—Continued.

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		NORTH CAROLINA—contd.								
Feb.	H. m.		° ′	° ′			Secs.			
21	23 40	Greensboro	36 05	79 50	3	3	2			A. R. Horry.
	23 40	Henderson	36 20	78 25		1	60			Enoch Powell.
	23 40	Hickory	35 45	81 22	5	1	40			F. B. Gwinn
	23 40	Highlands	35 02	83 24	4–5	1	60	Rumbling		B. C. Hawkins.
	23 40	Hot Springs	35 53	82 50	4	1	3			R. A. Garner.
	23 40	Lake Toxaway	35 05	82 56	5	1				C. B. McNulty.
	23 40	Lenoir	35 55	81 36	5	1	10	Rumbling		J. H. Beall.
	23 40	Lincolnton	35 27	81 18	5	1				J. T. McLean.
	23 40	Marion	35 54	82 02	4–5		15	Rumbling		Thos. McGuire.
	23 40	Marshall	35 47	82 40	4	2	20	Faint		M. L. Church.
	23 40	Morganton	35 45	81 38	4	2	15			J. B. P. Massey.
	23 40	Mount Airy	36 30	80 38		2				J. B. Sparger.
	23 40	Pinehurst	35 12	79 29		1	15			H. F. Sise.
	23 40	Raleigh	35 45	78 37		1				(Press report.)
	23 40	Salisbury	35 38	80 32						Thelma Wilkinson.
	23 40	Saluda	35 14	82 20	5	1				I. B. Cullipher.
	23 40	Settle	35 39	80 44	2	3	6			C. H. Smith.
	23 40	Skyland	35 30	82 30	6	2	20	Rumbling		A. B. Case.
	23 40	Southport	33 55	78 02	2	1				Mrs. C. E. Taylor.
	23 40	Statesville	35 45	80 55						D. M. Thompson.
	23 40	Swannanoa	35 36	82 23	4	2	12	Rumbling		J. M. Patton.
	23 40	Wilmington	34 14	77 57	3	2	Few.			U. S. Weather Bureau.
	23 40	Winston-Salem	35 06	80 17	3					H. E. Rondthaler.
		SOUTH CAROLINA.								
21	23 40	Anderson	34 30	82 39						H. H. Russell.
	23 40	Batesburg	33 50	81 38	3	1	5		Children frightened	J. M. Johnson.
	23 40	Belton	34 30	82 34	5	3	12			M. C. Clenkscales.
	23 40	Calhoun Falls	34 05	82 36	4	1	6		Dishes rattled	L. M. Parker.
	23 40	Chappells	34 09	81 52	2	1	2			J. J. Murran.
	23 40	Charleston	32 47	79 56	2	2	15			Miss Zoe St. Amand.
	23 40	Clemson College	34 39	82 52	4	1			Dishes rattled	R. N. Brackett.
	23 40	Columbia	34 00	81 03	2-3	2	14		Windows rattled	Stephen Taber.
	23 40	Gaffney	35 08	81 36	4	1	40			H. A. Parshall.
	23 40	Greenville	34 50	82 24	5	1	10			J. H. Woodside.
	23 40	Greenwood	34 10	82 10	2	2	5			M. M. Calhoun.
	23 40	Landrum	35 14	82 15	4	1				R. H. Wilds.
	23 40	Liberty	34 47	82 41	5	1	4	Rumbling	Furniture moved	J. T. Boggs.
	23 40	Little Mountain	34 09	81 24	2	1	6			J. M. Sease.
	23 40	Mountain Rest	34 52	83 09	5			Rumbling		J. H. Brown.
	23 40	Newberry	34 16	81 39	3-4	2	8			W. G. Peterson.
	23 40	Rock Hill	34 54	81 05	5	3	45	Rumbling	Shook buildings	W. P. Goodman.
	23 40	Santuck	34 35	81 35	5	2	5			E. W. Jetter.
	23 40	Spartanburg	34 52	81 58	5	1	20		Furniture moved	F. P. Robinson.
	23 40	Summerville	33 03	80 14	1-2	1				Miss E. H. Gadsden.
	23 40	Walhalla	34 45	83 04						N. F. Watt.
	23 40	Westminster	34 38	83 06	2	2	6			F. M. Crass.
		SOUTH DAKOTA.								
24	4 30	Pine Ridge	43 02	102 32	3	2	45			W. A. Spencer.
		TENNESSEE.								
21	23 40	Chattanooga	35 04	85 14	4	1	5			U. S. Weather Bureau.
	23 40	Elizabethton	36 20	82 10	4–5	1			Slight alarm	Chas. Boyd.
	23 40	Loudon	35 44	84 21	3	1	15			R. W. Clark.
	23 40	McMinnville	35 40	85 48						H. H. Stiles.
	23 40	Newport	35 56	83 12	4–5		5	Rumbling	Slight alarm	C. M. Babb.
	23 40	Sevierville	35 50	83 33	5	1	5	do	Bricks fell from chimneys	H. O. Eckel.
		UTAH.								
5	5 15	Elberta	39 58	111 58		1	2			D. C. Walker.
5	6 10	Elberta	39 58	111 58	5	1	2			D. C. Walker.
	6 10	Santaquin	40 00	111 46	6	1	30	Rumbling	Stopped clocks.	Wm. Broadbent.
		VIRGINIA.								
21	23 40	Norfolk	36 51	76 17	3	1				J. H. Cofer.
	23 40	Richmond	37 32	77 27	3	3				Mrs. H. B. McElrath.
	23 40	South Boston	36 43	78 57	3	1	15			C. B. Lacy.
	23 40	Wytheville	36 56	81 05	3	2	15			R. Ewald.
		WASHINGTON.								
22	11 45	Marietta	48 47	122 35	5	2	60			S. B. Mayhew.

TABLE 2.—*Instrumental reports, February, 1916.*

[Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.]

[For significance of symbols see REVIEW for January, 1916, p. 39.]

Alaska. *Sitka. Magnetic Observatory.* U. S. Coast and Geodetic Survey. J. W. Green.

Lat. 57° 03′ 00″ N.; long., 135° 30′ 06″ W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: {E V 10 T_0 16.7; N 10 15.4}

1916. Date.	Character.	Phase.	Time. H. m. s.	Period. T. Sec.	Amplitude. A_E μ	Amplitude. A_N μ	Distance. Km.	Remarks.
Feb. 6	.....	P_E	21 58 12	4	.....	.....	.....	P and S indistinct.
		S_E	22 02 01	.....	.....	.....	.....	
		L_N	22 05 00	22	.....	.....	.....	
		L_E	22 06 14	22	.....	.....	.....	
		M_E	22 07 38	20	370	.....	.....	
		M_N	22 14 44	16	.....	110	.....	
		C_N	22 15 00	12	.....	.....	.....	
		C_E	22 16 40	15	.....	.....	.....	
		F_E	23 24 00	.....	.....	.....	.....	
		F_N	23 38 00	.....	.....	.....	.....	
15	.....	P	11 37 41	4	.....	.....	.....	N–S not recording.
		L	11 39 42	13	.....	.....	.....	
		M	11 40 44	13	200	.....	.....	
		C	11 46 40	5	.....	.....	.....	
		F	12 15 00	.....	.....	.....	.....	
20	.....	P_E	17 52 20	2	.....	.....	.....	
		S_N	17 55 50	12	.....	.....	.....	
		M_N	17 55 58	12	.....	170	.....	
		L	18 00 03	16	.....	.....	.....	
		M_N	18 02 22	16	.....	100	.....	
		M_E	18 07 00	15	60	.....	.....	
		C	18 08 00	10	.....	.....	.....	
		F_E	18 40 00	.....	.....	.....	.....	
		F_N	18 54 00	.....	.....	.....	.....	
27	.....	eP	20 38 48	6	.....	.....	.....	N–S not recording.
		L	20 56 30	21	.....	.....	.....	
		M	21 06 48	15	100	.....	.....	
		C	21 12 00	11	.....	.....	.....	
		F	21 48 00	.....	.....	.....	.....	

Arizona. *Tucson. Magnetic Observatory.* U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat. 32° 14′ 48″ N.; long., 110° 50′ 06″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: {E V 10 T_0 16; N 10 19.6}

1916. Date.	Character.	Phase.	Time. H. m. s.	Period. T. Sec.	Amplitude. A_E μ	Amplitude. A_N μ	Distance. Km.	Remarks.
Feb. 3	.....	P	5 05 45	5	.....	.....	.....	
		L	5 06 45	.....	.....	.....	.....	
		M_E	5 06 50	5	20	.....	.....	
		M_N	5 07 38	6	.....	30	.....	
		F	5 19 00	.....	.....	.....	.....	
6	.....	eP_E	22 00 06	5	.....	.....	.....	
		eP_E	22 00 26	5	.....	.....	.....	
		S	22 08 29	6	.....	.....	.....	
		L_N	22 16 06	20	.....	.....	.....	
		L_E	22 18 14	22	.....	.....	.....	
		M_N	22 23 14	19	.....	20	.....	
		M_E	22 26 06	19	40	.....	.....	
		C	22 30 00	15	.....	.....	.....	
		F	23 38 00	.....	.....	.....	.....	
15	.....	e_N	11 42 34	4	.....	.....	.....	Barely perceptible.
		e_E	11 49 17	5	.....	.....	.....	
		M_N	11 48 04	16	.....	10	.....	
		M_E	11 59 47	11	10	.....	.....	
		F	12 20 00	.....	.....	.....	.....	
20	.....	P_N	17 56 20	4	.....	.....	.....	
		L_E	18 06 26	10	.....	.....	.....	
		L_N	18 07 00	17	.....	.....	.....	
		M_N	18 09 22	17	.....	30	.....	
		M_E	18 15 46	9	20	.....	.....	
		C_E	18 22 00	.....	.....	.....	.....	
		F_E	19 14 00	.....	.....	.....	.....	
27	.....	P	20 27 42	5	.....	.....	.....	
		L_N	20 37 42	17	.....	.....	.....	
		L_E	20 38 59	11	.....	.....	.....	
		M_E	20 41 20	18	1,040	.....	.....	
		M_N	20 46 21	18	.....	2,070	.....	
		C_E	20 48 00	13	.....	.....	.....	
		C_N	20 57 00	14	.....	.....	.....	
		F_N	21 59 00	.....	.....	.....	.....	
		F_E	22 28 00	.....	.....	.....	.....	

California. *Berkeley. University of California.*

Lat., 37° 53′ 16″ N.; long., 122° 15′ 37″ W. Elevation, 85.4 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Mount Hamilton. Lick Observatory.*

Lat., 37° 20′ 24″ N.; long., 121° 38′ 34″ W. Elevation, 1,281.7 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Point Loma. Raja Yoga Academy.* F. J. Dick.

Lat., 32° 43′ 03″ N.; long., 117° 15′ 10″ W. Elevation, 91.4 meters.

Instrument: Two-component, C. D. West seismoscope.

(Report for February, 1916, not received.)

California. *Santa Clara, University of.* J. S. Ricard, S. J.

Lat., 37° 26′ 36″ N.; long., 121° 57′ 03″ W. Elevation, 27.43 meters.

(See Record of the Seismographic Station, University of Santa Clara.

Colorado. *Denver. Sacred Heart College. Earthquake Station.* A. W. Forstall, S. J.

Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.

Instrument: Wiechert 80 kg., astatic, horizontal pendulum.

1916. Date.	Character.	Phase.	Time. H. m. s.	Period. T. Sec.	Amplitude. A_E μ	Amplitude. A_N μ	Distance. Km.	Remarks.
Feb. 1	.....	.....	.....	.....	.....	.....	.....	Activity on E–W from $3^h\ 30^m$ to 6^h.
2	.....	.....	.....	.....	.....	.....	.....	Pronounced activity on E–W from $14^h\ 30^m$ to 17^h, and activity on both components, larger on N–S, from $17^h\ 30^m$ to 19^h.
6	.....	P	22 06 —	.....	.....	.....	.....	P somewhat doubtful; S not discernible.
		L_E	22 18 —	25	.....	.....	.....	
		L_N	22 19 —	25	.....	.....	.....	
		M	22 20 —	26	.....	.....	.....	
		C_N	22 23 —	22–26	.....	.....	.....	
		C_E	22 26 —	22–26	.....	.....	.....	
		F	22 — —	.....	.....	.....	.....	
27	.....	P_E	20 24 —	.....	.....	.....	.....	P very clear; S obscure. Time is somewhat doubtful.
		S_E	20 29 —	.....	.....	.....	.....	
		L	20 35 —	22	4	4	.....	
		M_E	20 37 —	25	18	.....	.....	
		M_N	20 39 —	25	.....	18	.....	
		C_N	20 42 —	10	.....	5	.....	
		C_E	20 45 —	12	8	.....	.....	
		F_N	20 51 —	.....	.....	.....	.....	
		F_E	20 53 —	.....	.....	.....	.....	

District of Columbia. *Washington. U. S. Weather Bureau.*

Lat., 38° 54′ 12″ N.; long., 77° 03′ 03″ W. Elevation, 21 meters.

Instrument: Marvin (vertical pendulum), undamped. Mechanical registration.

Instrumental constants.. V 110 T_0 6

1916. Date.	Character.	Phase.	Time. H. m. s.	Period. T. Sec.	Amplitude. μ	Amplitude. μ	Distance. Km.	Remarks.
Feb. 1	I_V	P	7 55 16	.....	.....	.....	4,525?	
		S?	8 01 32	.....	.....	.....	.....	
		L	8 05 30	.....	.....	.....	.....	
1	I_U	P?	8 15 34	.....	.....	.....	8,715?	
		S?	8 25 30	.....	.....	.....	.....	
		L	8 33 00	.....	.....	.....	.....	
		L	8 44 30	18	.....	.....	.....	
3	I_V	P	5 17 49	.....	.....	.....	420	
		S	5 18 35	.....	.....	.....	.....	
		L?	5 19 17	.....	.....	.....	.....	
		F	5 30 00	.....	.....	.....	.....	F in microseisms.
6	.....	P	11 04 39	.....	.....	.....	.....	Slight trailers.

TABLE 2.—*Instrumental reports, February, 1916*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
District of Columbia. *Washington*—Continued.								
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb. 6	I_M	P	22 02 32				7,765	
		S	22 11 40					
		L	22 20 00					
		L	22 23 30					
		L	22 26 00	20				Long waves continued for a long time.
7		F	0 15 00					
8	I_M	P	15 43 25				5,735	
		S	15 50 47					
		F	16 15 00					
15	II_M	P	11 44 30				5,230	
		S	11 51 25					
		L	11 57 30					
		M	12 01 00		99	99		
		F	12 45 00					
20	I_M	P	17 57 59				6,750	Record on E-W very slight.
		S	18 06 15					
		L	18 13 10					
		L	18 17 35	16				
		F	19 45 00					
21	$II_?$	P	23 40 33				740	
		S	23 41 54					
		M	23 42 10		45	51		
		L	23 42 43					
		F	23 50 —					F in microseisms.
* 27	II_E	iP	20 27 14				3,330	
		S	20 32 20					
		L	20 35 30	26				L uncertain.
		M_E	20 36 30		191			
		M_N	20 39 30			200		
		F	22 — —					F in microseisms.

District of Columbia. *Washington. Georgetown University.*

F. L. Tondorf, S. J.

Lat., 38° 54′ 25″ N.; long., 77° 04′ 24″ W. Elevation, 42.4 meters. Subsoil: Decayed diorite.

Instruments: Wiechert 200 kg. astatic horizontal pendulums, 80 kg. vertical.

Instrumental constants:		V	T_0	ϵ
	E	165	5.4	2.6
	N	143	5.2	3.4
	Z	*80*	*3.0*	*0*

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb. 3	.....	e	4 17 23					Light microseisms at time of quake, becoming heavier later.
		P_E	4 18 31					
		P_N?	4 18 32					
		L_N	4 20 54					No maximum.
		L_E	4 20 56					
		F	4 29 00					
3	.....	e_E	5 08 15					
		e_N	5 08 30					
		i_N	5 09 29					F lost in microseisms.
6	.....	ePg_E	22 02 36					
		ePg_N	22 02 54					
		Sg_N?	22 11 36					
		Sg_E	22 11 53					
		eL_E	22 25 14					
		M_N	22 35 20	25		5		
		M_E	22 36 47	20	7			
7	.....	F	0 40 00					
			VERTICAL. A_Z					
6	.....	e	*22 17 48*					
		L	*22 32 02*					
		F	*23 00 00*					
8	.....	ePg_E	15 43 14					
		ePg_N	15 43 22					
		Sg_E	15 48 52					
		Sg_N	15 49 14					
		F	16 31 00					
11	.....	e	14 50 20					Microseisms present.
		F	15 50 00					
15	.....	ePg_N	11 43 30					
		ePg_E	11 43 35					
		Sg_N	11 51 19					
		Sg_E	11 51 20					
		i_N	12 00 10	8				
		i_E	12 00 19	8				
		M_E	12 01 04	10	16			
		M_N	12 01 06	10		12		
		F	13 12 00					

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
District of Columbia. *Washington*—Continued.								
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb. 20	.....	ePg_E	17 57 52					Microseisms present.
		ePg_N	17 57 55					
		Sg_E	18 06 17					
		Sg_N	18 06 22					
		eL_N	18 15 28					
		eL_E	18 15 58					No distinct maximum.
		F	19 30 00					
21	.....	ePg_N	23 40 47					Microseisms present.
		ePg_E	23 40 50					Mainka instrument gives P earlier and S later.
		S	23 41 50					
		eL	23 41 56	10				
		M	23 42 02	10	22	19		F lost in microseisms.
			VERTICAL. A_Z					
		e	*23 40 48*					Microseisms heavy.
		S	*23 41 56*					
		eL	*23 42 05*	*6*				
		M	*23 42 08*	*6*	*20*			
		F	*23 58 00*					
27	.....	P_N	20 26 55					
		P_E	20 27 15					
		S_E	20 32 19					
		S_N	20 32 27					
		eL	20 33 52	12				
		M_E	20 38 22	15	26			
		M_N	20 39 00	15		41		
		F	22 — —					F lost in wind markings.
			VERTICAL. A_Z					
		P	*20 27 03*					Heavy wind markings.
		S	*20 32 30*					
		L	*20 34 12*	*9*				
		M	*20 39 29*	*17*	*38*			
		F	22 — —					F lost in wind marks.

Hawaii. *Honolulu. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Wm. W. Merrymon.

Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.

Instruments: Milne seismograph of the Seismological Committee of the British Association.

Instrumental constant..	T_0 18.9

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb. 1	.....	P	7 46 48					
		S	7 55 00					
		L	8 04 30	22				
		M	8 13 24		*1,200			
		C	8 43 36					
1	.....	L	9 40 24	26				
		M	9 46 24		*350			This and the preceding quake overlap.
		C	9 53 24					
		F	11 07 54					
2	.....	eP	14 58 18					
		L	15 01 06	20				
		M	15 03 42		*150			
		C	15 05 24					
		F	15 11 36					
2	.....	L	17 57 36					
		M	18 01 12		*50			
		C	18 05 00					
2	.....	L	20 09 12					
		M	20 13 00		*50			
		C	20 24 00					
2	.....	P	21 44 06					
		S	21 50 30					
		L	21 56 06	22				
		M	22 00 24		*250			
		C	22 10 36					
		F	22 29 24					
3	.....	e	10 32 48	22				
		M	10 37 24		*150			
		C	10 43 42					
		F	11 03 12					
3	.....	e	19 37 00	20				
		M	19 43 18		*100			
		C	19 50 24					
		F	19 58 00					
6	.....	e	11 07 24	20				
		M	11 12 48		*200			
		C	11 23 12					
		F	11 49 48					

* Trace amplitude.

TABLE 2.—*Instrumental reports, February, 1916*—Continued.

Hawaii. *Honolulu*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb. 6	.....	P.....	21 59 06	.....	.....	.....	.....	
		S.....	22 03 36	.....	.....	.....	.....	
		L.....	22 07 12	21	.....	.....	.....	
		M.....	22 12 36	.....	*4,950	.....	.....	
		C.....	22 21 00	.....	.....	.....	.....	
7	.....	F.....	1 42 06	.....	.....	.....	.....	
8	.....	P.....	15 59 36	.....	.....	.....	.....	
		L.....	16 17 12	22	.....	.....	.....	
		M.....	16 00 06	.....	*100	.....	.....	
		M.....	16 19 36	.....	*50	.....	.....	
		C.....	16 25 24	.....	.....	.....	.....	
		F.....	16 39 18	.....	.....	.....	.....	
9	.....	e.....	20 34 36	22	.....	.....	.....	
		M.....	20 38 54	.....	*100	.....	.....	
		C.....	20 41 42	.....	.....	.....	.....	
		F.....	20 48 06	.....	.....	.....	.....	
9	.....	P.....	23 46 54	.....	.....	.....	.....	
		L.....	23 50 18	22	.....	.....	.....	
		M.....	23 53 00	.....	*150	.....	.....	
		C.....	23 56 48	.....	.....	.....	.....	
10	.....	F.....	0 09 42	.....	.....	.....	.....	
10	.....	eP.....	11 18 42	.....	.....	.....	.....	
		eL.....	11 24 48	20	.....	.....	.....	
		M.....	11 26 48	.....	*150	.....	.....	
		M.....	11 30 54	.....	*150	.....	.....	
		C.....	11 37 12	.....	.....	.....	.....	
		F.....	11 59 12	.....	.....	.....	.....	
11	.....	P.....	8 54 00	.....	.....	.....	.....	
		eL.....	9 15 36	22	.....	.....	.....	
		M.....	9 19 54	.....	*150	.....	.....	
		C.....	9 25 06	.....	.....	.....	.....	
		F.....	9 29 06	.....	.....	.....	.....	
14	.....	P.....	10 23 12	.....	.....	.....	.....	
		S.....	10 30 12	.....	.....	.....	.....	
		L.....	10 36 06	24	.....	.....	.....	
		M.....	10 40 06	.....	*500	.....	.....	
		C.....	11 02 06	.....	.....	.....	.....	
		F.....	11 32 54	.....	.....	.....	.....	
15	.....	eP.....	11 49 18	.....	.....	.....	.....	
		S.....	11 51 54	.....	.....	.....	.....	
		M.....	11 52 48	.....	*500	.....	.....	
		L.....	11 55 12	.....	.....	.....	.....	
		M.....	11 56 48	.....	*300	.....	.....	
		C.....	12 02 42	.....	.....	.....	.....	
		F.....	13 25 12	.....	.....	.....	.....	
20	.....	e.....	17 54 12	.....	.....	.....	.....	
		L.....	18 01 42	20	.....	.....	.....	
		M.....	18 02 18	.....	*950	.....	.....	
		M.....	18 08 06	.....	*700	.....	.....	
		C.....	18 52 12	.....	.....	.....	.....	
		F.....	21 07 06	.....	.....	.....	.....	
22	.....	L.....	20 20 48	.....	.....	.....	.....	
		M.....	20 22 00	.....	.....	.....	.....	
		C.....	20 35 00	.....	.....	.....	.....	
27	.....	P.....	20 32 36	.....	.....	.....	.....	
		S.....	20 41 12	.....	.....	.....	.....	
		L.....	20 53 12	22	.....	.....	.....	
		M.....	20 56 42	.....	3,150	.....	.....	
		C.....	21 24 30	.....	.....	.....	.....	
28	.....	F.....	0 25 30	.....	.....	.....	.....	

*Trace amplitude.

Kansas. *Lawrence. University of Kansas.* Department of Physics and Astronomy. F. E. Kester.

Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 301.1 meters.

Instrument: Wiechert.

Instrumental constants.. {E V 177 T_0 3.4 ϵ 4.0; N 205 3.4 3.8}

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb. 6	.....	P.....	22 01 35	.....	.....	.....	.....	
		S_E.....	22 09 28	.....	.....	.....	.....	
		S_N.....	22 09 34	.....	.....	.....	.....	
		L_N.....	22 17 39	.....	.....	.....	.....	
		L_E.....	22 19 33	.....	.....	.....	.....	
		M_E.....	22 26 11	20	4	.....	.....	
		M_N.....	22 29 51	20	.....	3	.....	
7	.....	F.....	0 05 00	.....	.....	.....	.....	

Kansas. *Lawrence*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb. 15	.....	P.....	11 43 17	2	.....	.....	.....	
		S_N.....	11 49 09	3–6	.....	.....	.....	
		S_E.....	11 49 12	3–6	.....	.....	.....	
		L_N.....	11 56 25	4–5	.....	.....	.....	
		L_E.....	11 56 30	4–5	.....	.....	.....	
		M_E.....	11 57 05	5	22	.....	.....	
		M_N.....	11 57 18	5	.....	5	.....	
		L.....	11 58 00 / 11 59 00	15–20	.....	.....	.....	
		F.....	12 36 00	.....	.....	.....	.....	
21	.....	P_E.....	23 41 12	2	.....	.....	.....	
		P_N.....	23 41 42	2	.....	.....	.....	
		L_N.....	23 43 48	.....	.....	.....	.....	L_E not discernible.
		M_E.....	23 44 03	.....	7	.....	.....	
		M_N.....	23 44 09	.....	.....	7	.....	
22	.....	F.....	0 06 00	.....	.....	.....	.....	
27	.....	P.....	20 27 14	2–4	.....	.....	.....	
		M.....	20 28 30	3–5	6	16	.....	
		S.....	20 32 35	3–12	.....	.....	.....	
		L_E.....	20 34 37	35–40	.....	.....	.....	
		L_N.....	20 36 18	35–40	.....	.....	.....	
		M_N.....	20 38 50	25–40	.....	15	.....	
		M_E.....	20 39 42	25–40	15	.....	.....	
		F.....	22 06 00	.....	.....	.....	.....	

Maryland. *Cheltenham. Magnetic Observatory.* U. S. Coast and Geodetic Survey. George Hartnell.

Lat., 38° 44′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants.. {E V 10 T_0 31; N 10 29}

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb 6	.....	eP_E.....	22 01 34	.....	.....	.....	.....	Beginning and end uncertain.
		eS.....	22 11 47	.....	.....	.....	.....	
		L.....	22 25 30	25	.....	.....	.....	
		M_N.....	22 34 49	17	.....	140	.....	
		M_E.....	22 36 48	18	150	.....	.....	
		C.....	22 46 00	18	.....	.....	.....	
		F.....	23 45 00	.....	.....	.....	.....	
15	.....	P_N.....	11 44 35	2	.....	.....	.....	
		S_N.....	11 51 29	2	.....	.....	.....	
		L.....	12 00 48	15	.....	.....	.....	
		M.....	12 03 40	14	50	50	.....	
		C.....	12 07 00	13	.....	.....	.....	
		F.....	12 29 00	.....	.....	.....	.....	
20	.....	eL_E.....	18 17 34	18	.....	.....	.....	
		eL_N.....	18 17 48	16	.....	.....	.....	
		M_E.....	18 24 40	18	30	.....	.....	
		M_N.....	18 32 24	16	.....	30	.....	
		F.....	19 10 00	.....	.....	.....	.....	
21	.....	e_E.....	23 42 06	3	.....	.....	.....	
		e_N.....	23 41 51	3	.....	.....	.....	
		M_N.....	23 42 16	3	.....	40	.....	
		M_E.....	23 42 40	3	30	.....	.....	
		C.....	23 43 00	.....	.....	.....	.....	
		F.....	23 48 00	.....	.....	.....	.....	
27	.....	P_N.....	20 27 12	3	.....	.....	.....	
		P_E.....	20 27 21	4	.....	.....	.....	
		S.....	20 32 30	10	.....	.....	.....	
		L_N.....	20 36 32	19	.....	.....	.....	
		L_E.....	20 38 45	18	.....	.....	.....	
		M.....	20 39 20	20	135	220	.....	
		C.....	20 41 00	16	.....	.....	.....	
		F.....	22 01 00	.....	.....	.....	.....	

Massachusetts. *Cambridge. Harvard University Seismographic Station.* J. B. Woodworth.

Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori 100 kg. horizontal pendulums (mechanical registration)

Instrumental constants.. {E V 80 T_0 23 ϵ:1 0; N 50 25 4:1}

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb. 1	.....	O?.....	7 25 00	.....	.....	.....	15,200?	Not registered on N–S.
		eP.....	7 41 24	2	.....	.....	.....	
		S.....	7 55 11	8	.....	.....	.....	
		eL.....	8 24 56	40	.....	.....	.....	
		L.....	8 33 22	20	.....	.....	.....	
		L.....	8 40 24	15	.....	.....	.....	
		F.....	9 02 00	.....	.....	.....	.....	

TABLE 2.—*Instrumental reports, February, 1916*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Massachusetts. *Cambridge*—Continued.								
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb. 3	.....	*O?*	*5 07 42*	.....	.....	.....	3,500?	
		eS_E	5 19 37	6	.....	.....	.....	
		eL_E	5 21 07	6	.....	.....	.....	
		L	5 22 13	6	.....	.....	.....	
		L	5 22 39	8	.....	.....	.....	
		F	5 32 00	.....	.....	.....	.....	
6	.....	*O?*	*21 49 51*	.....	.....	.....	9,670	
		eP_E	22 02 37	.....	.....	.....	.....	
		eP_N	22 03 05	2	.....	.....	.....	
		S_N	22 13 26	6	.....	.....	.....	
		M_E	22 28 35	.....	.....	.....	.....	
		M_E	22 35 05	.....	.....	.....	.....	
		eL_N	22 35 37	24	.....	.....	.....	
		eM_N	22 38 20	20	.....	75	.....	
		C_E	22 44 42	.....	.....	.....	.....	
7	.....	F	0 48 30	.....	.....	.....	.....	
15	.....	*O?*	*11 33 25*	.....	.....	.....	6,490	eP confused with microseisms.
		eP_E	11 43 24	.....	.....	.....	.....	
		S_N?	11 50 35	.....	.....	.....	.....	
		S_E	11 51 26	.....	.....	.....	.....	
		eL_E	11 55 24	.....	.....	.....	.....	
		L_N	11 55 32	7	.....	.....	.....	
		L_E	11 58 29	11–12	.....	.....	.....	
		eM_E	12 00 01	18	.....	.....	.....	
		M	12 00 31	18	.....	.....	.....	
		C_E	12 00 52	.....	.....	.....	.....	
		M_N	12 01 38	.....	.....	.....	.....	N–S pendulum shifted to the north.
		F	12 50 00	.....	.....	.....	.....	
20	.....	*O*	*17 48 05*	.....	.....	.....	6,520	
		eP_E	17 58 06	.....	.....	.....	.....	
		eP_N	17 58 15	.....	.....	.....	.....	
		S_E	18 06 10	.....	.....	.....	.....	
		eL	18 13 16	15	.....	.....	.....	
		L	18 16 12	10	.....	.....	.....	
		L	18 21 27	22	.....	.....	.....	
		L	18 26 07	.....	.....	.....	.....	
		L	18 28 00	.....	.....	.....	.....	
		F	19 40 00	.....	.....	.....	.....	
21	.....	*O?*	*23 39 00*	.....	.....	.....	1,390?	Earthquake reported in Georgia, Tennessee, etc. Record obscured by microseisms.
		P_N	23 42 00	.....	.....	.....	.....	
		S_N?	23 44 26	.....	.....	.....	.....	
		S_E	23 44 33	.....	.....	.....	.....	
		L_N	23 44 48	4	.....	.....	.....	
		M_N	23 44 56	.....	.....	.....	.....	
		L_E	23 45 03	8	.....	.....	.....	
		F_N	23 50 00	.....	.....	.....	.....	
22	.....	L_E	21 02 01	16–20	.....	.....	.....	
		L_E	21 13 48	15	.....	.....	.....	
		F	21 45 00	.....	.....	.....	.....	N–S out of service after 10h 26m, Feb. 24 because of spring of registering apparatus breaking.
27	.....	*O*	*20 20 45*	.....	.....	.....	3,950	
		iP?	20 28 00	4	.....	.....	.....	
		PKI	20 29 20	.....	.....	.....	.....	
		S	20 33 44	9	.....	.....	.....	
		S	20 34 50	.....	.....	.....	.....	
		eL?	20 35 00	20	.....	.....	.....	
		eL?	20 37 22	35	.....	.....	.....	
		M_E?	20 39 58	24	.....	.....	.....	Stylus went off drum.
		C	21 55 00	20	.....	.....	.....	
		L	22 45 20	18	.....	.....	.....	
		F	23 30 00	.....	.....	.....	.....	

O—time at origin.

Missouri. *Saint Louis. St. Louis University.* Geophysical Observatory. J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation: 12 feet of tough clay over limestone of Mississippi system, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

	V	T_0	*e*:1
Instrumental constants..	80	7	5:1

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb. 3	II_T	eP_N	5 10 12	.....	.....	.....	1,700	E–W record slight.
		S_N	5 12 48	.....	.....	.....	.....	
		L_N	5 13 18	.....	.....	.....	.....	
		M_N	5 13 30	10	.....	12	.....	
		F	5 19 00	.....	.....	.....	.....	
6	II_u	eP	22 02 00	.....	.....	.....	6,800?	
		S	22 10 18	.....	.....	.....	.....	
		L?	22 27 00	.....	.....	.....	.....	
		F	23 26 00	.....	.....	.....	.....	

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Missouri. *Saint Louis*—Continued.								
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb. 15	II_T	eP_N	11 53 00	.....	.....	.....	3,500	
		eP_E	11 53 30	.....	.....	.....	.....	
		S	11 58 00	.....	.....	.....	.....	
		L?	11 58 12	.....	.....	.....	.....	
		M_E	11 58 30	12	16	.....	.....	
		M_N	11 59 30	12	.....	16	.....	
		F_N	12 21 00	.....	.....	.....	.....	
20	II_u	eP_N	17 55 30	.....	.....	.....	6,500	
		eP_E	17 56 00	.....	.....	.....	.....	
		S	18 04 00	.....	.....	.....	.....	
		L?	18 13 00	.....	.....	.....	.....	
		M_N	18 19 24	20	.....	12	.....	
		M_E	18 29 42	17	9	.....	.....	
		F	19 54 00	.....	.....	.....	.....	
21	II_T	eP	23 40 18	.....	.....	.....	686	
		S	23 41 46	.....	.....	.....	.....	
		L	23 41 54	.....	.....	.....	.....	
		M_N	23 42 00	4	.....	12	.....	
		M_E	23 42 36	6	19	.....	.....	
		F	23 53 00	.....	.....	.....	.....	
27	III_T	eP_N	20 24 15	.....	.....	.....	3,200	
		eP_E	20 24 19	.....	.....	.....	.....	
		S_N	20 29 11	.....	.....	.....	.....	
		S_E	20 29 12	.....	.....	.....	.....	
		L_N	20 30 24	.....	.....	.....	.....	Waves varying between 7 and 5 mm. amplitudes, and 35s to 21s period occur from 20h 40m 35s to 20h 46m 03s.
		M_N	20 31 07	4	.....	53	.....	
		M_E	20 32 04	7	44	.....	.....	
		F	21 39 00	.....	.....	.....	.....	

New York. *Buffalo. Canisius College.* John A. Curtin, S. J.

Lat., 42° 53′ 02″ N.; long., 78° 52′ 40″ W. Elevation, 190.5 meters.

Instrument: Wiechert 80 kg. horizontal.

	V	T_0	*e*:1
Instrumental constants..	80	7	5:1

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb. 3	.....	.....	.....	.....	.....	.....	.....	Earthquake reported from Schenectady, N. Y., not recorded here. Records show only pronounced microseisms.
6	II_T	eP_E	22 15 20	.....	.....	.....	.....	
		eP_N	22 15 30	.....	.....	.....	.....	
		S_N	22 20 20	.....	.....	.....	.....	
		S_E	22 20 40	.....	.....	.....	.....	
		L	22 29 00	.....	.....	.....	.....	
		M_N	22 32 00	20	.....	8	.....	
		M_E	22 32 00	24	6	.....	.....	
		C_N	22 43 00	.....	.....	.....	.....	
		C_E	22 51 00	.....	.....	.....	.....	
		F_E	23 03 00	.....	.....	.....	.....	
		F_N	23 34 00	.....	.....	.....	.....	
11	I_T	i_N	14 50 30	.....	.....	.....	.....	Single shock.
		F_N	14 50 40	.....	.....	.....	.....	
15	II_T	eP_E	11 52 15	.....	.....	.....	.....	
		eP_N	11 52 30	.....	.....	.....	.....	
		S_E	11 56 00	.....	.....	.....	.....	
		S_N	11 56 10	.....	.....	.....	.....	
		M_E	12 01 10	10	14	.....	.....	
		M_N	12 01 30	6	.....	6	.....	
		C_E	12 03 20	.....	.....	.....	.....	
		C_N	12 04 00	.....	.....	.....	.....	
		F_N	12 08 00	.....	.....	.....	.....	
		F_E	12 15 00	.....	.....	.....	.....	
20	III_T	eP_E	18 01 30	.....	.....	.....	.....	
		eP_E	18 03 30	.....	.....	.....	.....	
		S_E	18 07 45	.....	.....	.....	.....	
		S_N	18 09 30	.....	.....	.....	.....	
		S_E	18 09 45	.....	.....	.....	.....	
		L	18 18 00	.....	.....	.....	.....	
		M	18 20 00	30	3	2	.....	Maximum weak on both components.
		M_N	18 25 00	20	.....	3	.....	
		M_E	18 27 00	20	4	.....	.....	
		C_N	18 30 00	.....	.....	.....	.....	
		C_E	18 37 00	.....	.....	.....	.....	
		F_N	19 00 00	.....	.....	.....	.....	
		F_E	19 21 00	.....	.....	.....	.....	
21	.....	eP	23 40 20	.....	.....	.....	.....	
		S	23 42 20	.....	.....	.....	.....	
		M_N	23 45 10	10	.....	11	.....	
		M_E	23 45 30	10	11	.....	.....	
		F_E	23 50 00	.....	.....	.....	.....	
		F_N	23 51 00	.....	.....	.....	.....	
26	.....	.....	.....	.....	.....	.....	.....	Microseisms on both components.

TABLE 2—*Instrumental reports, February, 1916*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
New York. *Buffalo*—Continued.								
1916. Feb. 27	III,	iP_N	*H. m. s.* 20 26 00	*Sec.*	μ.	μ.	*Km.*	Reported in San Jose, Costa Rica, and Rivas, Nicaragua.
		eP_E	20 26 15					
		S_N	20 31 20					
		S_E	20 31 35					
		L_N	20 34 00					
		L_E	20 34 45					
		M_E	20 35 20	20	28			
		M_N	20 36 00	20		66		
		C_N	20 43 00					
		C_E	20 44 00					
		F_N	21 27 00					
		F_E	21 50 00					
New York. *Fordham. Fordham University.* W. C. Repetti, S. J. Lat., 40° 51′ 47″ N.; long., 73° 53′ 08″ W. Elevation, 23.9 meters. Instrument: Wiechert, 80 kg. Instrumental constants.. E: V 72, T_0 7.2, c:1 1.5:1; N: V 72, T_0 7.2, c:1 3.8:1 (Report for February, 1916, not received.)								
Panama Canal Zone. *Balboa Heights.* Isthmian Canal Commission. Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, 27.6 meters. Instruments: Two Bosch-Omori 100 kg. Instrumental constants.. V 10, T_0 20								
1916. Feb. 3	.....	P_N	*H. m. s.* 9 04 13	*Sec.*	μ.	μ.	*Km.*	Distance and direction unknown.
		P_E	9 04 20					
8	.....	P_N	15 55 39				210	Direction SW?
		P_E	15 55 46					
		L_N	15 56 03					
		M_N	15 56 08			5,300		
		L_E	15 56 09					
		M_E	15 56 14		5,150			
		F_N	16 09 05					
		F_E	16 09 42					
8	.....	P	16 10 46				210	No record on E-W, adjusting instrument.
		L	16 11 01					
		M	16 11 25			10		Direction SW?
8	.....	P_E	17 57 32				210	Direction SW?
		P_N	17 57 45					
		L_E	17 57 56					
		M_E	17 57 59		300			
		L_N	17 58 11					
		M_N	17 58 28			100		
		F_N	18 04 50					
		F_E	18 05 42					
8	.....	P	18 13 00					Distance and direction unknown.
9	.....	P_E	2 45 04				210	Direction unknown.
		P_N	2 45 12					
		L_E	2 45 39					
		L_N	2 45 40					
		M_E	2 45 42		100			
		M_N	2 45 44			100		
		F_N	2 49 07					
		F_E	2 49 16					
27	.....	P_N	20 23 15				865	Direction NE?
		P_E	20 23 16					Pens thrown off sheet: amplitudes greater than those given.
		L_N	20 24 58			2,200		
		L_E	20 25 04		2,900			
		F_E	21 06 00					
		F_N	21 30 00					

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Porto Rico. *Vieques. Magnetic Observatory.* U. S. Coast and Geodetic Survey. H. M. Pease. Lat., 18° 09′ N.; long., 65° 27′ W. Elevation, 19.8 meters. Instruments: Two Bosch-Omori. Instrumental constants.. E: V 10, T_0 21.4; N: V 10, T_0 21.1 (Report for February, 1916, not received.)								
Vermont. *Northfield. U. S. Weather Bureau.* Wm. A. Shaw. Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters. Instruments: Two Bosch-Omori, mechanical registration. Instrumental constants.. E: V 10, T_0 15; N: V 10, T_0 16								
1916. Feb. 1	.....	P	*H. m. s.* 7 54 30	*Sec.*	μ	μ	*Km.*	Phases indistinct. Small waves continue until 8h 15m.
1	.....	L	8 38 00					Slight disturbance, mostly long waves. Phases indistinct.
		F	9 10 00					
3	.....							Faint irregularities from 4h 24m to 4h 28m; probably New York quake.....
3	.....	P?	5 17 10				980?	
		S?	5 18 56					
		L	5 20 20					
		F	5 30 00					
6	.....	L	22 18 50	24				Beginning and earlier portion of record lost during attention to instrument.
		L	22 25 00	28				
		F	24 00 00					
15	.....	P?	11 43 52				5,700?	
		S?	11 51 12					
		L	11 57 00					
		F	12 30 00					
20	.....	P?	17 58 06				5,665?	
		S?	18 05 24					
		L	18 16 30					
		F	19 30 00					
21	.....							Slight disturbances from 6h 42m to 6h 42m 15s. Probably due to earthquake reported from Georgia, South Carolina, etc.
27	.....	P	20 27 51				3,925	
		S	20 33 34					
		L	20 38 40	28				
		M	20 43 30		250	200		
		F	22 30 00					
Canada. *Ottawa. Dominion Astronomical Observatory.* Earthquake Station. Otto Klotz. Lat., 45° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters. Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical seismograph. Instrumental constants: V 120, T_0 26								
1916. Feb. 1	.....	P	*H. m. s.* 7 49 36	*Sec.*	μ	μ	*Km.* 11,000	
		S_E	8 01 11	7				
		S_N	8 01 17					
		eL_E	8 23 54	40				
		L_E	8 28 00	18				
		L_E	8 35 00	18				
		L	8 40 00 – 9 19 00	18–15				
		F	9 40 00					

TABLE 2.—*Instrumental reports, February, 1916*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			Canada. *Ottawa*—Continued.					
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb. 3	.....	P_N	5 17 14	.....	.....	.....	1,430	
		S_N	5 19 44	.....	.....	.....	.....	
		L_E	5 20 28	10	.....	.....	.....	
		F	5 42 00	.....	.....	.....	.....	
6	.....	eP_N	11 04 09	2	.....	.....	3,900?	
		iP_N	11 04 10	2	.....	.....	.....	
		i_N	11 13 36	2	.....	.....	.....	
		i_E	11 13 50	6	.....	.....	.....	
		i_E	11 15 00	10	.....	.....	.....	F lost in microseisms.
6	.....	P_N	22 02 10	.....	.....	.....	7,100	
		S_E	22 10 44	.....	.....	.....	.....	
		SR2?	22 18 00	20	.....	.....	.....	
		eL_E	22 23 36	30	.....	.....	.....	
		L	22 25 00	24	.....	.....	.....	
		L	22 32 00	17	.....	.....	.....	
		L_E	22 35 00	19	.....	.....	.....	
		L_E	22 45 00	12	.....	.....	.....	
		L_E	23 01 00	12	.....	.....	.....	
		L_E	23 10 00	11	.....	.....	.....	
		L_E	23 21 00	10	.....	.....	.....	
		L_E	23 30 00	11	.....	.....	.....	
		L_E	23 40 00	11	.....	.....	.....	
7	.....	F	1 10 00	.....	.....	.....	.....	
8	.....	eL_E	16 13 36	24	.....	.....	.....	
		L_E	16 18 00	16	.....	.....	.....	
		F	16 25 00	.....	.....	.....	.....	
14	.....	$PR1_N$?	10 32 37	.....	.....	.....	8,100?	
		$PR2_N$?	10 34 16	.....	.....	.....	.....	
		i	10 35 22	.....	.....	.....	.....	
		$SR1_N$?	10 43 51	.....	.....	.....	.....	
		$SR2_N$?	10 47 37	.....	.....	.....	.....	
		eL?	10 55 24	20	.....	.....	.....	
		L_E	11 10 00 11 17 00	20	.....	.....	.....	
		F	11 25 00	.....	.....	.....	.....	
15	.....	P	11 43 59	2	.....	.....	4,660	
		PR1	11 45 36	.....	.....	.....	.....	
		S	11 50 23	.....	.....	.....	.....	
		SR2	11 53 52	.....	.....	.....	.....	
		eL_E	11 55 24	12	.....	.....	.....	
		eL_N	11 55 48	24	.....	.....	.....	
		M	11 59 06	.....	.....	.....	.....	
		L	12 20 00	16–12	.....	.....	.....	
		F	13 00 00	.....	.....	.....	.....	
20	.....	P	17 57 32	2	.....	.....	6,260	
		eS_E	18 05 19	.....	.....	.....	.....	
		iS_E	18 05 26	.....	.....	.....	.....	
		eL_E	18 15 24	24	.....	.....	.....	
		eL_N	18 16 00	20	.....	.....	.....	
		L	18 18 00	30	.....	.....	.....	
		M	18 19 00	24	40	10	.....	
		L	18 24 00	16	.....	.....	.....	
		L_E	18 30 00	20	.....	.....	.....	
		L	18 35 00 19 12 00	15–12	.....	.....	.....	
		F	20 00 00	.....	.....	.....	.....	
27	.....	eP_E	20 28 10	.....	.....	.....	4,100	
		eP_N	20 28 11	2	.....	.....	.....	
		iP_N	20 28 13	.....	.....	.....	.....	
		$PR1_N$	20 29 34	.....	.....	.....	.....	
		eS	20 34 04	.....	.....	.....	.....	
		iS_N	20 34 18	.....	.....	.....	.....	
		eL_N	20 38 30	30	.....	.....	.....	
		L	20 40 00	24–20	.....	.....	.....	
		M_E	20 42 00	20	24	.....	.....	
		M_N	20 42 42	20	.....	42	.....	
		L	20 45 00	16	.....	.....	.....	
		L	20 55 00	16–14	.....	.....	.....	
		L	21 06 00	13	.....	.....	.....	
		L	21 13 00	13	.....	.....	.....	
		L	21 25 00 22 08 00	13	.....	.....	.....	
		F	23 00 00	.....	.....	.....	.....	

* Trace amplitude.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			Canada. *Toronto. Dominion Meteorological Service.*					
			Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.					
			Instrument: Milne horizontal pendulum, North. In the meridian.					
			Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom=0.59″.					
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb. 1	.....	S?	8 02 54	.....	.....	.....	.....	Phases not well defined.
		L	8 09 54	.....	.....	.....	.....	
		L	8 16 12	.....	.....	.....	.....	
		L	8 20 00	.....	.....	.....	.....	
		L	8 37 48	.....	.....	.....	.....	
		L	8 42 06	.....	.....	.....	.....	
		M	8 44 12	.....	*1,700	.....	.....	
		L	9 13 18	.....	.....	.....	.....	
		L	10 28 42	.....	*200	.....	.....	
		F	10 33 12	.....	.....	.....	.....	
6	.....	L	11 13 12	.....	.....	.....	.....	Isolated thickening.
		L	11 36 06	.....	.....	.....	.....	
		M	11 37 24	.....	*200	.....	.....	
		F	11 46 24	.....	.....	.....	.....	
6	.....	P	22 01 00	.....	.....	.....	.....	
		P	22 02 42	.....	.....	.....	.....	
		IS	22 11 12	.....	.....	.....	.....	S waves prolonged and well defined.
		S?	22 18 42	.....	.....	.....	.....	
		L	22 20 30	.....	.....	.....	.....	
		L	22 23 30	.....	.....	.....	.....	
		L	22 25 06	.....	.....	.....	.....	
		L	22 27 36	.....	*3,400	.....	.....	
		L	22 32 00	.....	.....	.....	.....	
		M	22 34 48	.....	*4,800	.....	.....	
		M	22 41 54	.....	*4,300	.....	.....	
7		F	0 24 30	.....	.....	.....	.....	
8	.....	P	15 52 36	.....	.....	.....	.....	Marked little disturbance.
		P	15 59 18	.....	.....	.....	.....	
		S	16 03 18	.....	.....	.....	.....	
		L	16 15 36	.....	.....	.....	.....	
		L	16 17 36	.....	.....	.....	.....	
		M	16 18 36	.....	*600	.....	.....	
		F	16 49 48	.....	.....	.....	.....	
10	.....	L?	10 42 48	.....	.....	.....	.....	Phases not pronounced.
		L	11 02 12	.....	.....	.....	.....	
		L	11 29 06	.....	.....	.....	.....	
		M	11 35 42	.....	*300	.....	.....	
		F	11 54 12	.....	.....	.....	.....	
15	.....	P?	11 45 48	.....	.....	.....	.....	P not defined; may not have been recorded. Marked quake.
		IS	11 50 18	.....	.....	.....	.....	
		S	11 53 42	.....	.....	.....	.....	
		IL	11 58 24	.....	.....	.....	.....	
		M	12 01 00	.....	*1,600	.....	.....	
		L	12 03 54	.....	.....	.....	.....	
		F	13 15 12	.....	.....	.....	.....	
20	.....	S	18 05 12	.....	.....	.....	.....	Well-defined quake. P lost during attention to instrument.
		L	18 13 18	.....	.....	.....	.....	
		L	18 18 24	.....	.....	.....	.....	
		M	18 26 18	.....	*800	.....	.....	
		L	18 30 42	.....	.....	.....	.....	
		L	18 46 24	.....	.....	.....	.....	
		L	18 49 46	.....	.....	.....	.....	
		F	20 00 02	.....	.....	.....	.....	
22	.....	eL	21 01 30	.....	.....	.....	.....	A marked gradual increase and decrease in thickening.
		M	21 06 06	.....	*400	.....	.....	
		F	21 18 30	.....	.....	.....	.....	
27	.....	P	20 24 36	.....	.....	.....	.....	A well-defined disturbance.
		P	20 30 00	.....	.....	.....	.....	
		IS	20 34 06	.....	.....	.....	.....	
		L	20 37 06	.....	.....	.....	.....	
		L	20 38 06	.....	.....	.....	.....	
		M	20 42 12	.....	*9,700	.....	.....	
		M	20 47 18	.....	*7,300	.....	.....	
		M	20 51 24	.....	*6,200	.....	.....	
		L	20 57 30	.....	.....	.....	.....	
		L	21 09 18	.....	.....	.....	.....	
		L	22 33 00	.....	.....	.....	.....	
		F	23 55 12	.....	.....	.....	.....	
28	.....	L	20 19 48	.....	*100	.....	.....	Doubtful as to being seismic.
		F	20 27 06	.....	.....	.....	.....	

* Trace amplitude.

TABLE 2.—*Instrumental reports, February, 1916*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Canada. *Victoria, B. C. Dominion Meteorological Service.*								
Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.								
Instrument: Wiechert, vertical; Milne horizontal pendulum, North. In the meridian.								
Instrumental constant.. T_0 18. Pillar deviation, 1 mm., swing of boom=0.54″.								
1916. Feb. 1	.....	P	*H. m. s.* 7 54 13	*Sec.*	μ	μ	*Km.* 1,730	
		S	7 57 11	.....	.....	.....	.....	
		L	7 58 41	.....	.....	.....	.....	
		M	7 59 11	.....	*300	.....	.....	
		F	8 07 36	.....	.....	.....	.....	
1	.....	S?	8 16 02	.....	.....	.....	.....	
		L	8 24 58	.....	.....	.....	.....	
		M	8 28 25	.....	*900	.....	.....	
		F	9 38 51	.....	.....	.....	.....	
3	.....	P or S.	5 05 40	.....	.....	.....	270	
		L	5 06 10	.....	.....	.....	.....	
		M	5 06 40	.....	*400	.....	.....	
		F	5 10 40	.....	.....	.....	.....	
6	.....	L	11 09 16	.....	.....	.....	.....	Thickening.
		M	11 10 37	.....	*200	.....	.....	
		F	11 17 34	.....	.....	.....	.....	
6	.....	P	21 58 13	.....	.....	.....	.....	
		P	22 01 12	.....	.....	.....	.....	
		iS	22 03 40	.....	.....	.....	.....	
		S?	22 05 48	.....	.....	.....	.....	
		L	22 09 12	.....	.....	.....	.....	
		M	22 19 32	.....	*2,500	.....	.....	
7	.....	F	0 00 40	.....	.....	.....	.....	
8	.....	L	15 54 42	.....	*100	.....	.....	
		F	15 56 00	.....	.....	.....	.....	
10	.....	L	11 44 48	.....	.....	.....	.....	P and S not visible.
		M	11 52 43	.....	*400	.....	.....	
		F	12 03 38	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	.....	.....	No reports received after the 12th.

* Trace amplitude.

SEISMOLOGICAL DISPATCHES.[1]

Schenectady, N. Y., Feb. 2, 1916.

A distinct earthquake shock was felt here at 11:25 o'clock to-night. Reports from all sections of the county showed houses were shaken, windows and dishes smashed, and persons thrown out of bed. Two distinct shocks were felt. The shocks were of such force as to shake the mammoth plant of the General Electric Co., where it was feared an explosion had occurred. Saratoga Springs, Amsterdam, and all points within a radius of 25 miles of this city also felt the shock. (Assoc. Press.)

Panama, Feb. 8, 1916.

Three sharp earth shocks occurred between 11 and 11:14 a. m. to-day. The whole city and the Canal Zone were shaken. The recording instruments showed that the earthquake had its center in the vicinity of Los Santos Province, where most of the earthquakes originate. (Assoc. Press.)

Fort De France, Martinique, Feb. 12, 1916.

A large earthquake occurred at 11:13 o'clock last night. No damage. (Assoc. Press.)

Stuttgart, Feb. 15, 1916.

A severe earthquake occurred in the Swabian Alps region last Sunday, February 13. Five villages were severely damaged, but no loss of lives has been reported. (Inter. News Service.)

Redding, Cal., Feb. 21, 1916.

Lassen Peak is showing renewed activity, according to reports received from residents of Hat Creek Valley. The crater, they say, is constantly emitting smoke and steam, although in small amounts. The volcano could be seen from here to-day to be in mild eruption. (Assoc. Press.)

Atlanta, Ga., Feb. 21, 1916.

An earth tremor of slight but distinct nature that made itself felt throughout Georgia, North and South Carolina, Virginia, and portions of eastern Tennessee and Alabama was reported early to-night as having been felt at about 5:45 p. m., central time. (Assoc. Press.)

[Many similar reports received from other points in the affected district.]

San Juan del Sur, Nicaragua, Feb. 27, 1916.

An earthquake shock which was felt at 2:33 o'clock this afternoon is reported to have been very severe in San Jose, Costa Rica, and in the Department of Rivas, Nicaragua. The principal church in the town of Rivas was damaged. No deaths have been reported. (Assoc. Press.)

Quebec, Feb. 29, 1916.

Three successive shocks resembling an earthquake were distinctly felt all over the Quebec district at about 12:15 a. m. to-day. The local observatory reported no seismograph record of the disturbance and was mystified. (Assoc. Press.)

TABLE 3.—*Late seismological reports.* (*Instrumental.*)

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Porto Rico. *Vieques. Magnetic Observatory.* U. S. Coast and Geodetic Survey. H. M. Pease.								
Lat., 18° 09′ N.; long., 65° 27′ W. Elevation, 19.8 meters.								
Instruments: Two Bosch-Omori.								
Instrumental constants.. V E 10 N 10; T_0 E 21.4 N 21.1								
1916. Jan. 1	.....	e_E	*H. m. s.* 14 27 36	*Sec.* 34	μ	μ	*Km.*	
		e_N	14 28 02	32	.....	.....	.....	
		M_N	14 37 58	20	.....	150	.....	
		M_E	14 40 22	20	75	.....	.....	
		C_N	14 48 00	9	.....	.....	.....	
		C_E	14 51 00	8	.....	.....	.....	
		F_E	15 15 00	.....	.....	.....	.....	
		F_N	15 19 00	.....	.....	.....	.....	
7	.....	L	15 04 36	.....	.....	.....	.....	Felt in Vieques.
		M	15 04 40	.....	80	100	.....	
		C	15 05 02	.....	.....	.....	.....	
13	.....	e_E	9 04 00	44	.....	.....	.....	
		e_N	9 25 00	40	.....	.....	.....	
		M_N	9 46 00	20	.....	80	.....	
		M_E	9 55 00	20	20	.....	.....	
		C_N	10 24 00	20	.....	.....	.....	
		C_E	10 30 00	.....	.....	.....	.....	

[1] Reported by the organization indicated and collected by the seismological station at Georgetown University, Washington, D. C.

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological and seismological work and studies:

Abbot, C[harles] G[reeley].
Arequipa pyrheliometry. Washington. 1916. 24 p. 24½ cm. (Smithsonian miscellaneous collections, v. 65, no. 9.) [Summarized in this issue of the REVIEW, p. 63.]

Barbour, T.
Some remarks upon Matthew's "Climate and evolution." With supplemental note by W. D. Matthew. New York. 1916. 15 p. 24½ cm. (Annals of the New York academy of sciences, v. 27, pp. 1–15.)

Batchelor, L. D., & West, F. L.
Variation in minimum temperatures due to the topography of a mountain valley in its relation to fruit growing. Logan, Utah. 1915. 27 p. 23 cm. (Utah agricultural experiment station. Bulletin no. 141.)

Canada. Department of the interior. Irrigation branch.
Report on the climatic and soil conditions in the Canadian Pacific railway company's irrigation project, western section (near Calgary, Alberta). Ottawa. 1915. 24 p. 24½ cm. (Irrigation series, bulletin no. 3.)

Canada. Meteorological service.
Upper air investigations in Canada. Part 1. Observations by registering balloons, by J. Patterson. Ottawa. 1915. 127 p. 25 cm. (M. S. 51.)

Chile. Instituto central meteorológico y geofísico.
Anuario meteorológico de Chile. Segunda parte (resúmenes). 1913. [In Spanish and German.] Santiago de Chile. 1915. vi, 134 p. plates. 37½ cm. (Publicaciones, no. 15.)
Valores horarios de elementos meteorológicos en Los Andes 1911 y 1912. [In Spanish and German.] Santiago de Chile. 1915. 3 p. l., 81 p. plates. 37½ cm. (Publicaciones, no. 16.)
Valores horarios de los elementos meteorológicos, temperatura del suelo y dispersión eléctrica en Santiago 1914. [In Spanish and German.] Santiago de Chile. 1915. 2 p. l., 91 p. plates. 37½ cm. (Publicaciones, no. 17.)

Clark, A. L.
Introduction to the study of cloud formations. (*In* Queen's quarterly, Queen's University. Kingston, Canada. v. 23, no. 3. Jan.-Mar., 1916. p. 248–260. plates.

Cocks, Gerhard H.
Experimental studies of the effect of various atmospheric conditions upon the upper respiratory tract [conducted under the auspices of the New York State commission on ventilation]. 48 p. 23½ cm. (Read before the American laryngological, rhinological, and otological society, at the 21st annual meeting, Chicago, June, 1915.)

Davos. Meteorologische Station.
Jahres-Uebersicht der Beobachtungen, 1915. Davos. [1916.] 3 leaves. 30½ x 46 cm. (Anhang zu den vom Kurverein Davos herausgegebenen Monatswetterkarten.)

Day, William H.
Lightning; its nature, and the efficiency and methods of lightning protection. (*In* Journal, Royal astronomical society of Canada. Toronto. March, 1916. v. 10, p. 121–133.)

Fetherston, J. T.
Snow removal in New York City. (*In* Municipal engineers journal. New York. Nov., 1915. v. 1, p. 339–381.)

Huntington, Ellsworth.
A neglected factor in race development. p. 167–184. 23 cm. (Reprinted from the Journal of race development, v. 6, no. 2, October, 1915.) [Treats of climatic variations in relation to race development.]
Weather and civilization. 21 p. plates. (Reprinted from the Bulletin of the Geographical society of Philadelphia, v. 14, no. 1, January, 1916.)

Klotz,, Otto.
Seismological tables. Ottawa. 1916. 2 p. l., 19–61 p. 2 pl. 29 cm. (Publications of the Dominion observatory, v. 3, no. 2.)

Kimball, Herbert H.
Daylight illumination, and the intensity and duration of twilight. 17 p. 23 cm. (Read at a meeting of the Pittsburgh section of the Illuminating engineering society, Cleveland, Ohio, Feb. 18, 1916.) [See this REVIEW, January, 1915, **44**:12–13.]

Lewis, Merwyn R.
Solar halo of May 20, 1915. (*In* Proceedings, Delaware county institute of science. Media, Pa. 1916. v. 7, p. 49–66.)

Marbitz, Heinz.
Phänologische Beobachtungen in Pommern. Greifswald. 1914. p. 369–383. 22 cm. (S.-A. aus dem 14. Jahresbericht der Geographischen Gesellschaft zu Greifswald 1913/14.)

Masciari-Genoese, F.
Trattato di costruzioni antisismiche, preceduto da un corso di sismologia. Milano. 1915. xxviii, 1004 p. illus. plates. 24 cm.

Norway. Meteorologiske institut.
Veiledning 1. Meteorologiske iagttagelser 1. Kristiania. 1915. 47 p. tab. 23 cm.

Palmer, George T.
A new sampling apparatus for the determination of aerial dust. p. 54–55. 24½ cm. (Reprinted from American journal of public health, Boston, v. 6, no. 1.)
An outline of the activities of the New York State commission on ventilation for the year 1915. 18 p. 25 cm. (Presented at the annual meeting of the American society of heating and ventilating engineers, New York, Jan. 20, 1916.)
The part played by temperature in school-room ventilation. 8 p. 24½ cm. (Reprinted from School and society, v. 2, no. 28, July 10, 1915.)

Philippine islands. Weather bureau.
Annual report, 1914. Part 1–2. Manila. 1915. 140 p. 29½ cm.

Saderra Masó, Miguel.
Historia del Observatorio de Manila, 1865–1915. Manila. 1915. 210 p. plates. 27 cm.

Shreve, Forrest.
The vegetation of a desert mountain range as conditioned by climatic factors. Washington. 1915. 112 p. 36 pl. 25½ cm. (Carnegie institution of Washington. Publication no. 217.)

Stonyhurst college observatory.
Results of meteorological, magnetical, and seismological observations, 1915. Blackburn. 1916. xiii, 52 p. 18½ cm.

U. S. Lighthouse service.
The United States Lighthouse service, 1915. Washington. 1916. 94 p. 23 cm. [Fog signals, p. 40–46.]

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled. It shows only the aricles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

American society of civil engineers. Proceedings. New York. v. 42. March, 1916.

Binckley, George S., & Lee, Charles H. Suggested changes and extensions of the United States Weather bureau service in California. Discussion by Fred. H. Tibbetts. p. 379–382.

Duryea, Edwin, Jr., & Haehl, H. L. A study of the depth of annual evaporation from Lake Conchos, Mexico. Discussion by Charles W. Comstock. p. 383–402.

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SECTION VII.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

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[Dated: Weather Bureau, Washington, April 1, 1916.]

PRESSURE.

The distribution of the mean atmospheric pressure over the United States and Canada and the prevailing direction of the winds are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

For the month as a whole the mean barometric pressure was below the normal in the eastern Canadian Provinces, the New England and Atlantic Coast States, east of the Appalachian Mountains, and the coastal portions of Washington, Oregon, and northern California, but in all other sections it was above the normal. The negative departures as a rule were small, the greatest values appearing along the southern New England coast, but, on the other hand, the positive departures were quite marked in the western Plains States and the northern Rocky Mountain region.

The month opened with relatively high pressure throughout practically all sections of the country, except in New England and the eastern Canadian Provinces, where it was near or slightly below the normal. The extensive high pressure area which covered the greater part of the country was replaced in most sections by somewhat lower pressure toward the middle of the first decade; but pressure above the normal continued generally throughout the second decade, except for an occasional low area which crossed the country. However, during the third decade several rather extensive and well-defined low and high pressure areas followed one another at rather infrequent intervals from the far West to the Atlantic. The month closed with relatively low pressure in all sections, except in the extreme northern portion of the Plains States, the upper Mississippi Valley, and the Canadian Provinces to the northward, where it was near or somewhat above normal.

The distribution of the highs and lows was generally favorable for westerly winds in New England, the Middle Atlantic States, and Lake region, northwesterly in the Ohio and Mississippi Valleys and Plains States, and northerly in the central Gulf States. Elsewhere variable winds prevailed.

TEMPERATURE.

The month opened with temperature above the average in the Atlantic Coast States but with low readings in the central and western districts. The cold area moved slowly eastward and temperatures below the normal prevailed in most sections east of the Rocky Mountains until the middle of the first week, freezing weather extending to the Gulf coast and northern Florida. Toward the latter part of the week a second cold wave appeared in the Northwest and extended into the lower Missouri Valley and to the eastward, reaching the northeastern districts by the end of the week.

During the early part of the second week the temperature was above the average in the South and over the Plains States, but colder weather obtained along the northern border, and during the next few days an area of low temperature moved from the Northwest southeastward to the Atlantic. Warmer weather appeared in the West about the end of the second week and gradually overspread the country to the eastward, but colder weather followed during the next few days, which in turn gave way to much warmer from the Mississippi Valley eastward, although it continued cold in the northeast. No marked changes in temperature occurred during the fourth week until near its end, when colder weather obtained in the eastern and northeastern districts. The month closed somewhat colder than average in the eastern and slightly warmer in the western districts.

For the month as a whole temperatures were below the normal in New England, the Lake region, and central valleys and above in the far western and southwestern States.

Extremes of temperature.—The extremes of temperature were generally well within the limits of previous years, except about the middle of the month, when the highest previously recorded in February were approached or equaled in portions of California and the Plains States and during the latter part of the month in southern Texas. Freezing weather occurred in all parts of the country at some time during the month, except southern Florida, portions of California, and southwestern Arizona, while zero temperatures were experienced as far south as southern Pennsylvania, the central valley States, southwestern Kansas, and at practically all stations in the Rocky Mountain region.

PRECIPITATION.

The month opened with stormy weather but mostly light precipitation in the Eastern States, while throughout the central portion of the country fair weather prevailed, but on the 2d and 3d heavy sleet and snow occurred in the New England and Middle Atlantic States. During the first week a low-pressure area moved from the North Pacific to the Atlantic Ocean, accompanied by generally light precipitation, except in portions of Washington, Oregon, and Idaho, where heavy snow fell. However, toward the latter part of the week fair weather prevailed generally in the South.

Early in the second week fairly heavy rain fell in the southeastern States and during the latter part moderate precipitation occurred in portions of Texas and thence northeastward to the Ohio Valley. In the northern part of the country light snow occurred almost daily during this week. Fair weather prevailed in practically all sections the third week, except for frequent light snows from the Great Lakes eastward in the latter half. During the first half of the fourth week a low-pressure area moved from the South Pacific across the country, accompanied by light precipitation in the Southwest, moderate rain in the Southern States, except heavy along the coast, and snow in the Ohio Valley and Lake region. Another storm area moved from the Pacific to the South Atlantic coast the latter part of the month, accompanied by moderate precipitation and thunderstorms in the southeastern States. The month closed with light rain in the North

Pacific and northern Plains States and from the Great Lakes southward and southeastward.

The precipitation for the month as a whole was quite generally below the average, except in the western portions of Washington and Oregon, southern Idaho, most of New York, New Jersey, and the New England States. In much of Texas, eastern Colorado, and New Mexico either no precipitation or only a trace occurred; and throughout most of the remainder of the western Plains States and eastern Rocky Mountain slope the precipitation was less than half an inch.

Snowfall.—There was a good snow cover in the extreme Northern States throughout most of the month, but in much of the winter-wheat belt there was little snow covering and some damage resulted. In the extreme Northwestern States unusually heavy snows occurred, and at the close of the month large quantities had accumulated in the higher mountain regions; thus prospects of a plentiful supply of water for the coming growing season were good in nearly all portions of the western mountain regions.

GENERAL SUMMARY.

The weather for the month was generally favorable for outdoor operations in most of the Southern States, but in the North it was generally cold and disagreeable. The cold weather about the middle of the month did some damage to truck in the South and to citrus bloom in northern Florida.

The weather was favorable for a good ice harvest of excellent quality in the northeastern States, but farther south the amount harvested during the winter is, on the average, less than will be required. The month closed with most of the Great Lakes harbors covered with ice. On the Mississippi and Missouri Rivers and their tributaries, however, but little ice remained except in the northern portions. Truck plantings in the South were generally later than usual, and in the lower Mississippi Valley farm operations were delayed by floods.

Average accumulated departures for February, 1916.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	°F.	°F.	°F.	Ins.	Ins.	Ins.	Per ct.		Per ct.	
New England	22.6	−3.1	+ 1.7	4.11	+0.70	−1.30	6.6	+1.3	76	+ 1
Middle Atlantic	31.2	−1.7	+ 4.7	3.54	+0.20	−1.30	6.4	+0.9	71	− 3
South Atlantic	48.1	+0.4	+ 8.0	3.26	−0.90	−3.20	4.1	−1.2	72	− 4
Florida Peninsula	65.7	−1.2	+ 5.2	1.65	−1.00	−2.70	3.5	−0.8	76	− 4
East Gulf	49.7	−1.1	+ 6.4	2.96	−2.00	−3.30	4.5	−1.1	70	− 6
West Gulf	51.2	+1.5	+ 6.4	0.56	−2.30	−0.50	4.6	−1.0	69	− 5
Ohio Valley and Tennessee	33.1	−2.6	+ 4.1	2.26	−1.30	+1.00	6.5	+0.3	75	+ 1
Lower Lakes	20.3	−4.3	+ 2.8	2.47	−0.10	+0.20	7.3	+0.5	81	+ 1
Upper Lakes	16.1	−3.0	+ 0.3	0.82	−1.00	+0.20	7.5	+1.2	81	− 1
North Dakota	6.8	−0.2	−10.2	0.40	−0.20	+0.20	4.2	−0.8	85	+ 5
Upper Mississippi Valley	23.0	−1.6	+ 1.2	0.66	−1.10	+1.70	5.7	+0.5	80	+ 3
Missouri Valley	25.0	+0.6	− 2.5	0.49	−0.60	−1.80	4.7	−0.5	81	+ 6
Northern slope	23.9	+2.4	−10.9	0.59	−0.20	+0.30	5.1	0.0	72	+ 1
Middle slope	34.7	+2.3	− 0.8	0.17	−0.60	+0.20	3.8	−0.6	68	+ 1
Southern slope	50.1	+4.6	+ 7.6	0.01	−0.90	−1.10	3.2	−1.6	48	−14
Southern Plateau	46.8	+1.9	+ 0.6	0.18	−0.50	+1.80	3.0	−0.6	47	+ 3
Middle Plateau	36.5	+3.5	− 0.7	0.74	−0.40	+1.50	5.2	+0.1	72	+ 8
Northern Plateau	33.9	+1.8	− 7.1	2.26	+0.80	+1.10	6.8	+0.6	77	+ 2
North Pacific	43.8	+2.5	− 5.0	8.06	+2.20	+1.20	6.7	−0.4	83	+ 2
Middle Pacific	52.9	+3.9	− 0.2	3.31	−1.10	+5.10	6.3	+0.7	79	+ 3
South Pacific	56.6	+4.0	− 2.2	1.63	−0.90	+7.40	5.1	+0.8	76	+ 7

WEATHER CONDITIONS IN THE NORTH ATLANTIC DURING FEBRUARY, 1915.

The data presented are for February, 1915, and comparison and study of the same should be in connection with those appearing in the REVIEW for that month. Chart IX (XLIV–20) shows for February, 1915, the averages of pressure, temperature, and the prevailing direction of the wind at Greenwich mean noon, together with the locations and courses of the more severe storms of the month.

PRESSURE.

The mean atmospheric pressure for the month was in many respects considerably different from the normal as shown on the Meteorological Chart of the North Atlantic for February. The Azores high was about 10 degrees east of its usual position, but was of normal intensity. Two highs were located in the eastern part of the United States, the first with a crest of 30.15 inches central near Charlotte, N. C., the eastern boundary extending along the coast from New York to northern Florida. The second high, of limited extent and the same intensity, was central in northern New York, separated from the first by a slight depression. The greatest difference in the pressure conditions from the normal is shown in the position of the Icelandic low of 29.4 inches central near latitude 58° N., longitude 10° W., where the normal pressure is 29.7 inches and about 10 degrees southeast of its usual location.

STORMS.

The large difference in pressure and comparatively short distance between the Azores high and the Icelandic low were responsible for the unusual number of gales on that part of the ocean between the two great centers of action. In the waters west of the 50th meridian, the number of gales was, as a rule, above the normal, but in others the number was below. The month was noted for the large differences in general conditions between the first and last periods. A good example of this may be shown in the 5-degree square between the 45—50th parallels and the 10—15th meridians, where the normal percentage of gales of 48 miles per hour and over is 18. For February, 1915, gales were observed in this square on 14 days, a percentage of 50. Nine of these gales occurred in the first decade of the month, four in the second, and only one in the last eight days. In the waters adjacent to the American coast the number of gales was somewhat above the normal, and they were as a rule fairly well distributed throughout the month, although between the 30—40th parallels and west of the 60th meridian, where the percentage ranged from 11 to 29, they all occurred after the 16th.

Three storm tracks are shown on Chart IX, although there were a number of disturbances whose courses were either too irregular to chart or it was impossible to plot their positions accurately on account of lack of observations.

On February 1 a low (1 on Chart IX) was central near latitude 53° N., longitude 30° W. There were but few observations received north of the center and the heaviest winds evidently prevailed in the southwest quadrant, where several vessels reported west and northwest gales of from 50 to 75 miles per hour, with snow and hail. It then moved a short distance in a southwesterly direction, and on the 2d was near latitude 50°, longitude 33°. The steamship *Pretorian* (Brit.), about 5 degrees south of the center, reported a barometer reading of 27.83 inches, and the steamship *Oosterdyk* (Dtch.), near by at the time, one of

27.96 inches. These were among the lowest barometer readings received in this office for years, and as both vessels were equipped with mercurial barometers, recently compared, the readings may be considered comparatively reliable. The following data were taken from the storm log of the *Pretorian* for February 2, her position for the period from 8 a. m. to 2 p. m. (local time) being given as latitude 49° 39′ N., longitude 34° 15′ W.:

Time.	Wind.		Barometer.
	Direction.	Force per hour.	
		Miles.	*Inches.*
8 a. m.	se.	56	28.25
10 a. m.	s.	48	27.95
11 a. m.	sw.	56	27.85
Noon.	w-nw.	28	27.79
2 p. m.	nw.	90	28.07

Barometer readings were corrected and reduced to sea level.

From the above it can be seen that the *Pretorian* was near the center of the storm at noon when the velocity of the wind and the barometer reading were both at their minimum.

This storm covered a large area and winds of hurricane force prevailed between the 15–50th meridians along the northern trans-Atlantic sailing routes. From its position on the 2d, the storm curved toward the north, and on the 3d the approximate position of its center was at latitude 57°, longitude 19°, although it was impossible to plot it accurately on account of lack of observations. The barometer had risen slightly, although the wind still retained its high velocity, and the storm area was nearly as large as on the previous day. The steamer *Texas* (Swed.) reported a northeasterly hurricane of 90 miles per hour near latitude 57° N., longitude 20° W., and a number of other vessels encountered winds of extremely high velocity, with hail and snow.

On the 15th there was a low (II on Chart IX) of 29.50 inches near latitude 51° N., longitude 40° W. The winds were moderate near its center, although in the vicinity of latitude 45°, longitude 42°, several vessels encountered west and northwest gales of from 40 to 50 miles per hour, with hail and snow. This disturbance moved in an easterly direction and on the 16th was near latitude 51°, longitude 25°. The barometer had fallen to 29.14 inches, and the winds increased in velocity, being especially strong in the southwest quadrant where the steamer *Idaho* (Brit.), at latitude 46° N., longitude 39° W., reported a northwest wind of 90 miles per hour, with hail and snow. The storm then increased its rate of translation and turning to the northeast was near latitude 56° N., longitude 13° W. on the 17th. Heavy winds prevailed over a large area, although the maximum velocity of 60 miles per hour was somewhat less than on the day before. After the 17th the movement of the storm was slow, and on the 18th it was central near latitude 58° N., longitude 10° W.; the winds in the southwest quadrant continued to decrease in violence, although gales of from 40 to 55 miles per hour were still encountered. The low continued its slow eastward movement, and on the 19th the center was off the north coast of Scotland. The winds as a rule were moderate, though four vessels in a small area near latitude 45°, longitude 21° W., reported gales of from 40 to 55 miles. The storm then curved slightly to the north and on the 20th the center was near Sumburgh Head, the most southerly point of the Shetland Islands. Winds of high velocities covering a slightly larger territory than on the previous day prevailed, accompanied by hail and snow, between the 45–50th parallels and the 10–20th meridians. This low remained nearly stationary for the next two days, and on the 23d was fast filling in.

On the 18th a low (III on Chart IX) appeared near latitude 31° and longitude 71°. This caused heavy north and northeast winds along the American coast between Norfolk and Jacksonville, three vessels reporting velocities of more than 60 miles, with hail and snow. The disturbance moved rapidly in an easterly direction and on the 19th was near latitude 36°, longitude 62°. In spite of this easterly movement, heavy gales still prevailed along the coast, covering slightly more territory than on the day before. On the 20th the low was near latitude 36°, longitude 59°, the barometer reading 29.57 inches. The difference in pressure between this point and the American coast was very large and several vessels reported strong northeast gales, with hail and snow. The low then turned sharply toward the north, and on the 21st was near latitude 39°, longitude 56°, heavy gales between this point and the coast still continuing. The disturbance recurved toward south, and on the 22d was about 3 degrees east of its position on the 20th. The winds along the coast moderated considerably, although gales were still encountered near the center and a short distance to the north of it. The storm then moved in a nearly due easterly course with a comparatively uniform rate of speed, and on the 23d was near latitude 35°, longitude 53°, the area being less in extent, only one vessel reporting winds of over 50 miles. On the 24th the low was near latitude 35°, longitude 47°, and while the territory with heavy winds was small, two vessels near the center encountered gales of from 50 to 75 miles. The steamer *Ikbal* (Brit.) in her storm log reported a barometer reading of 29.01 inches at 3 a. m. (local time) on February 24, her position being given as latitude 35° 40′, longitude 49° 18′. The low continued in its easterly movement, and on the 25th was near latitude 35°, longitude 42°. The barometer had risen since the previous day and the winds decreased in force, the maximum velocities reported being from 40 to 50 miles. From this point the disturbance began to lose force and on the 26th was central near latitude 35°, longitude 37°, but the winds had decreased and the barometer risen, the low rapidly filling in, so that no trace of it could be seen on the 27th. This track was remarkable for the fact that it was unusually far south, and the normal condition of high pressure in the vicinity of the Azores and the Bermudas was completely reversed for several days, causing storms of unusual violence for the locality.

TEMPERATURE.

The temperatures between the 10—40th meridians were, as a rule, not far from the normal, as the departures ranged from −1° to +3° in this area, while in the waters adjacent to the European coast they varied from −1° between the 55—60th parallels to +5° off the coast of Portugal. Between the 45—50th parallels and the 40—50th meridians the temperatures were slightly below the normal, increasing to the southward and westward. The highest positive departure was 8°, and occurred in the 5-degree square between the 35—40th parallels and the 60—65th meridians, while in the Gulf of Mexico the departures ranged from 0° to −4°. The temperature departure at a number of the Weather Bureau stations on the Atlantic and Gulf coasts were as follows: Eastport, +6.2°; Portland, +4.6°; Boston, +4.2°; Nantucket,

+2.4°; New York, +4.5°; Washington, +4.3°; Norfolk, +5.6°; Hatteras, +1.2°; Charleston, −0.2°; Key West, −2.4°; Tampa, −0.6°; Pensacola, −2.1°; and New Orleans, −0.1°. The lowest temperature reported during the month was −15° and occurred on the 2d and 4th in the Gulf of St. Lawrence and the waters to the northeast of it. Away from the influence of the shore the lowest temperature recorded was 5° on February 4 in the 5-degree square between the 50—55th parallels and the 45—50th meridians. The highest temperature was 82° and occurred on the 26th in the waters adjacent to the Panama Canal Zone.

FOG.

There was less fog than usual during the month off the Banks of Newfoundland, where the normal percentage of days with fog is 30 or more. In February, 1915, fog was observed in that locality on 5 days, a percentage of 18. On the other hand, in the area between the 45—50th parallels and the 30—35th meridians—where the normal percentage is less than 5—in the month under discussion it was observed on 4 days, or a percentage of 14. No fog was reported along the American coast south of the 45th parallel and the same conditions prevailed in the waters adjacent to the European coast north of that line. In the 5-degree square between the 40—45th parallels and the 15—20th meridians fog was observed on 3 days during the latter part of the month, a percentage of 11, while the normal for the same square varies from less than 5 to 5 or slightly more.

PRECIPITATION.

Hail was reported on 10 days and snow on 11 on the northern trans-Atlantic steamer routes, most of it occurring before February 20.

Maximum wind velocities, February, 1916.

Stations.	Date.	Velocity.	Directions.	Stations.	Date.	Velocity.	Directions.
		Mis./hr.				*Mis./hr.*	
Atlanta, Ga.	13	50	nw.	North Head, Wash	13	54	se.
Block Island, R. I.	7	64	w.	Do.	28	54	nw.
Do.	19	72	nw.	Point Reyes Light, Cal.	4	55	s.
Do.	27	58	nw.	Do.	29	52	nw.
Do.	28	60	nw.	Providence, R. I.	7	50	nw.
Buffalo, N. Y.	4	51	w.	Do.	19	60	w.
Do.	7	70	w.	Do.	28	65	w.
Cheyenne, Wyo.	7	60	w.	Sandy Hook, N. J.	7	58	w.
Hatteras, N. C.	14	54	n.	Do.	19	63	w.
Do.	19	51	nw.	Do.	21	50	nw.
Jacksonville, Fla.	25	50	w.	Do.	27	58	w.
Lander, Wyo.	7	56	w.	Do.	28	50	w.
Mt. Tamalpais, Cal	4	53	s.	Syracuse, N. Y.	18	52	nw.
Do.	9	56	s.	Tatoosh Island, Wash.	1	58	e.
Do.	10	60	s.	Do.	2	88	ne.
Do.	29	53	sw.	Do.	3	61	e.
New York, N. Y.	7	65	w.	Do.	8	55	e.
Do.	18	53	nw.	Do.	9	52	s.
Do.	19	64	nw.	Do.	10	62	s.
Do.	26	60	nw.	Do.	13	56	s.
Do.	27	75	nw.	Do.	17	62	e.
Do.	28	62	nw.	Do.	28	58	w.
Norfolk, Va.	19	50	nw.	Seattle, Wash.	10	54	sw.
North Head, Wash	2	54	s.	Trenton, N. J.	19	54	nw.
Do.	7	50	sw.	Do.	27	50	nw.
Do.	9	62	s.				
Do.	10	60	sw.				

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data, as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, February, 1916.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	47.2	+0.3	2 stations	80	9	Oneonta	10	3	4.00	−1.58	Benton	10.14	Cordova	1.49
Arizona	51.0	+4.7	Parker	92	18	Fort Valley	−20	1	0.55	−0.76	Crown King	2.08	3 stations	0.00
Arkansas	43.4	+1.8	Hot Springs	82	17	2 stations	6	2	1.78	−1.80	Helena	4.43	Whitecliffs	0.06
California	49.8	+1.3	Deer Creek	96	11	Bridgeport	−23	1	3.94	−0.47	Magalia	31.59	6 stations	0.00
Colorado	29.5	+3.5	Hoehne	74	10	Dillon	−45	1	0.90	−0.41	Steamboat Springs	4.21	8 stations	0.00
Florida	60.2	+0.3	Fort Meade	88	29	Fenholloway	21	16	1.16	−2.44	Miami (2)	4.87	Arcadia	0.00
Georgia	49.2	+2.1	Glenville	84	1	3 stations	15	3†	3.83	−1.34	Adairsville	7.05	St. George	0.37
Hawaii (January)	68.9	.....	2 stations	89	18†	Volcano House, Hawaii.	44	8†	18.22	.....	Kalawao, Molokai	37.67	Mana Pump, Kauai	5.98
Idaho	29.9	+1.6	do	63	23	Pierson	−29	28	2.82	+0.73	Arrowrock	7.99	Imus Bros. ranch	0.40
Illinois	27.2	−0.7	do	69	20	Lanark	−18	2	0.95	−1.58	Golconda	2.20	Aledo	0.22
Indiana	28.1	−0.1	3 stations	69	22	Shelbyville	−12	8	1.33	−1.50	Vevay	3.70	Collegeville	T.
Iowa	19.0	−1.5	Sioux City	61	19	Rock Rapids	−32	2	0.55	−0.60	Nara Springs	1.38	Osage	0.05
Kansas	32.3	+1.6	Hoxie	79	20	2 stations	−15	1	0.27	−0.93	Moran	1.58	Deerfield	0.00
Kentucky	34.9	−0.5	2 stations	72	22	Maysville	− 4	14	2.97	−0.77	Catlettsburg	4.90	Paducah	1.23
Louisiana	53.4	+1.3	Plain Dealing	88	18	Antioch	14	2	1.58	−3.09	Lakeside	5.47	Sugartown	0.00
Maryland-Delaware	32.1	+0.4	3 stations	69	1	Deer Park, Md	−11	14	3.31	+0.14	Annapolis, Md	5.71	Clear Spring, Md	2.16
Michigan	17.3	−1.0	Durand	55	18†	Ewen	−29	13	1.05	−0.87	Benzonia	2.94	2 stations	0.20
Minnesota	6.9	−3.7	Little Falls	51	17	Detroit	−46	13	0.47	−0.22	Caledonia	1.28	New London	T.
Mississippi	47.7	−0.1	2 stations	79	12†	2 stations	14	3	2.70	−2.33	Austin	5.05	Holly Bluff	0.73
Missouri	31.4	+0.4	Hollister	78	20	Bethany	−12	2	0.98	−1.48	Vandalia	3.00	Mount Vernon (2)	0.21
Montana	21.6	+0.8	Fort Shaw	68	15	Hingham	−44	3	0.95	+0.11	St. Marys Lake	5.70	3 stations	T.
Nebraska	26.8	+2.4	Superior	83	17	Stanton	−28	2	0.39	−0.35	North Platte	0.81	Stratton	0.00
Nevada	36.8	+4.0	Logan	80	15†	Millet	−25	1	0.89	−0.13	Marlette Lake	3.20	Oasis ranch	0.05
New England	20.3	−2.3	Cornish, Me	59	1	Enosburg Falls, Vt	−34	14	4.17	0.90	Rutland, Mass	6.38	Williamstown, Mass	1.53
New Jersey	28.1	−2.0	5 stations	63	1	2 stations	−18	15	4.21	+0.20	Lakewood	6.17	Pleasantville	2.84
New Mexico	41.2	+3.9	2 stations	89	11	Haynes	−35	1	0.21	−0.49	Bateman's ranch	3.04	40 stations	0.00
New York	18.8	+2.5	Oneonta	62	1	Raquette Lake	−33	14	3.48	+0.70	Rome	8.13	Chazy	0.75
North Carolina	42.9	+1.3	Greenville	82	1	Jefferson	5	14†	4.08	−0.22	Highlands	6.50	Belhaven	1.98
North Dakota	6.4	−1.1	3 stations	52	15†	Hillsboro	−38	13	0.46	−0.04	Orange	2.30	2 stations	0.00
Ohio	26.5	−1.1	2 stations	69	22	Summerfield	−18	14	1.83	−0.99	Thurman	4.48	Ottawa	0.52
Oklahoma	41.0	+1.8	Snyder	87	17	Hooker	− 7	1	0.26	−1.02	Webbers Falls	1.34	9 stations	0.00
Oregon	39.8	+1.8	McKinley	76	25	Agency Plains	− 9	2	5.10	+1.89	Golden Falls	20.22	Ana River	0.28
Pennsylvania	25.7	−1.8	York	67	1	Corry	−23	21	3.08	+0.18	Clearfield	5.86	Everett	1.30
Porto Rico	73.8	+0.4	2 stations	94	14†	2 stations	52	7†	3.63	+0.98	RioGrande(ElVerde)	12.18	Guanica Centrale	0.00
South Carolina	48.5	+1.6	3 stations	81	1	Darlington	11	15	3.96	−0.48	Pelzer	6.86	Georgetown	1.00
South Dakota	18.4	+0.4	Fort Meade	72	16	Britton	−35	2	0.40	−0.17	Harvey's ranch	1.35	2 stations	T.
Tennessee	39.6	+0.1	2 stations	76	17	Crossville	2	15	2.76	−1.57	Newport	5.83	Dyersburg	1.00
Texas	53.0	+3.1	do	99	28	Lieb (near)	− 2	1	0.09	−1.95	McKinney	0.92	72 stations	0.00
Utah	31.0	+1.4	Black Rock	80	9	Fort Duchesne	−36	1	1.21	−0.06	Silver Lake	6.17	3 stations	T.
Virginia	37.1	+1.0	2 stations	78	1	2 stations	− 5	14†	3.48	−0.18	Clarksville	5.33	Lincoln	1.09
Washington	33.9	−0.7	do	72	18†	3 stations	−11	1†	5.32	+1.99	South Bend	16.91	Harrington	0.67
West Virginia	31.4	−0.7	Beckley	72	12	Mannington	−12	14	4.30	+1.31	Pickens	9.19	Piedmont	1.79
Wisconsin	13.3	−2.1	Winter	58	16	Winter	−43	13	0.78	−0.36	Glen Flora	2.20	Lake Mills	0.14
Wyoming	24.7	+2.9	Pinebluff	76	16	Eden	−39	1	0.98	−0.01	Sand Lake	5.84	Hyattville	0.01

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations, making simultaneous observations at 8 a. m. and 8 p. m., daily, 75th meridian time, and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes)	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches)	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case *the record is broken at the end of each 50 minutes*, the accumulated amounts being recorded on successive lines until the excessive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

The tipping-bucket mechanism is *dismounted* and removed when there is danger of snow or water freezing in the same. Table II records this condition by entering an asterisk (*).

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high areas; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., 75th meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading or (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 33 years (1873 to 1905) and are published in Weather Bureau Bulletin "R," Washington, 1908. Stations whose records were too short to justify the preparation of normals in 1908 have been provided with normals as adequate records became available, and all have been reduced to the 33-year interval 1873–1905. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13–16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observation, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2 of the annual report just mentioned. The correction, t_0-t, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind-direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given. Chart VIII is published only when the general snow cover is sufficiently extensive to justify its preparation.

Chart IX.—Average values of pressure, temperature, and prevailing wind directions, and storm tracks over the North Atlantic Ocean, *for the corresponding month of last year*.

TABLE I.—*Climatological data for United States Weather Bureau stations, February, 1916.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.											Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.										Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea-level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.						Total.	Departure from normal.	Days with 0.01 or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.									
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*		°*F.*	°*F.*		°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*In.*	*In.*		*Miles.*											*0–10*	*In.*	*In.*
New England.							**22.6**	**— 3.1**										**4.11**	**+ 0.7**	**76**													**6.6**		
Eastport	76	67	85	29.82	29.91	— .07	19.4	— 2.0	49	1	26	—12	21	13	30	18	13	76	2.65	— 1.1	15	7,372	w.	40	ne.	25	7	6	16	6.8	21.8	T.			
Greenville	1,070	6	....	28.70	29.93	.....	11.9	.....	44	1	22	—22	21	2	38	.....	.....	....	3.34	.....	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20.7	.....	.....
Portland, Me	103	82	117	29.84	29.97	— .05	20.6	— 3.2	53	1	28	— 5	21	13	33	18	11	66	4.30	+ 0.5	15	7,326	n.	32	w.	7	8	6	15	6.1	20.2	1.4			
Concord	288	70	79	29.64	29.98	— .06	20.0	— 3.6	55	1	29	—15	15	11	44	.....	.....	....	4.18	+ 0.8	13	4,412	w.	31	w.	7	9	10	10	5.6	21.3	2.7			
Burlington	404	11	48	29.54	30.02	— .01	14.6	— 3.3	47	1	22	—15	14	7	26	.....	.....	....	2.32	+ 0.9	18	8,188	s.	42	nw.	7	4	12	13	6.9	17.1	6.8			
Northfield	876	12	60	29.00	29.99	— .05	14.7	— 2.5	52	1	24	—24	14	6	30	13	10	84	2.71	+ 0.4	18	5,090	n.	30	sw.	7	4	5	20	7.6	19.7	9.1			
Boston	125	115	188	29.83	29.97	— .07	25.5	— 2.5	57	1	33	0	21	18	31	23	16	69	5.18	+ 1.6	13	8,548	w.	36	w.	19	9	8	12	5.9	30.3	0.5			
Nantucket	12	14	90	29.93	29.94	— .10	29.8	— 2.8	53	25	36	6	21	24	39	28	24	79	4.04	+ 0.8	14	13,602	w.	48	w.	19	6	8	15	7.3	13.2	....			
Block Island	26	11	46	29.94	29.97	— .09	28.1	— 3.1	49	1	34	5	21	22	26	26	24	84	3.59	— 0.8	15	15,532	w.	72	nw.	19	9	2	18	7.1	9.8	....			
Narragansett Pier	....	9	....	.....	.....	.....	25.3	— 3.0	50	1	33	— 4	21	17	38	.....	.....	....	5.45	.....	14	.....	w.	.....	.....	.....	.....	11	6	12	....	17.0	T.		
Providence	160	215	251	29.79	29.97	— .09	24.6	— 4.4	56	1	32	0	14	17	32	23	18	78	4.34	— 0.2	16	10,991	w.	65	w.	28	10	6	13	6.1	15.1	T.			
Hartford	159	122	140	29.82	30.00	— .06	23.4	— 3.8	53	1	31	— 8	15	16	41	21	15	72	5.72	+ 2.0	15	5,939	nw.	36	sw.	7	9	3	17	6.6	24.6	3.1			
New Haven	106	117	155	29.87	30.00	— .07	25.5	— 2.8	53	1	33	— 2	15	18	34	22	18	75	6.21	+ 2.3	18	7,775	n.	37	n.	25	8	6	15	6.6	24.7	3.8			
Middle Atlantic States.							**31.2**	**— 1.7**										**3.54**	**+ 0.2**	**71**													**6.4**		
Albany	97	102	115	29.91	30.02	— .05	20.6	— 3.0	51	1	28	— 8	15	13	33	18	13	72	3.23	+ 0.6	17	5,946	nw.	28	nw.	19	7	6	16	6.6	13.7	1.5			
Binghamton	871	10	69	29.06	30.03	— .05	20.2	— 4.5	50	1	28	—14	15	13	3	.....	.....	....	3.15	+ 1.2	16	3,087	nw.	27	w.	7	5	6	18	7.2	21.4	5.8			
New York	314	414	454	29.66	30.01	— .07	27.7	— 3.0	61	1	35	1	14	20	26	24	18	66	4.49	+ 0.6	13	14,266	nw.	75	nw.	27	6	7	16	6.8	11.4	....			
Harrisburg	374	94	104	29.65	30.07	— .02	28.2	— 1.7	54	1	35	5	14	21	27	25	19	70	2.67	— 0.1	10	5,977	nw.	35	nw.	7	7	6	16	6.8	12.3	T.			
Philadelphia	117	123	190	29.91	30.05	— .05	31.3	— 1.5	61	1	38	5	14	24	27	28	21	66	3.55	+ 0.1	13	8,313	nw.	42	nw.	19	8	8	13	6.3	8.2	....			
Reading	325	81	98	29.69	30.06	.....	27.9	.....	55	1	35	2	15	21	29	25	19	70	3.64	0.0	14	6,195	nw.	36	nw.	27	7	4	18	6.9	11.1	T.			
Scranton	805	111	119	29.14	30.04	— .04	23.6	— 3.3	55	1	31	— 4	14	16	36	21	16	74	4.48	+ 1.7	18	5,786	sw.	40	sw.	7	7	5	17	6.9	19.7	0.2			
Atlantic City	52	37	48	29.98	30.04	— .07	31.7	— 1.3	56	1	39	4	15	25	27	29	24	77	4.54	+ 1.2	9	6,861	nw.	32	nw.	19	5	9	15	6.8	5.0	....			
Cape May	18	13	49	30.04	30.06	— .05	32.8	— 1.3	53	23	39	5	14	26	26	.....	.....	....	3.95	+ 0.6	11	7,624	nw.	40	nw.	27	6	13	10	6.4	6.1	....			
Sandy Hook	22	10	57	29.99	30.02	.....	28.9	.....	60	1	35	6	14	23	23	26	22	78	4.60	.....	14	14,516	w.	63	w.	19	7	9	13	6.3	12.9	....			
Trenton	190	159	183	29.81	30.02	.....	27.8	.....	62	1	35	0	14	21	27	25	21	76	3.16	+ 0.2	11	9,892	nw.	54	nw.	19	8	5	16	6.7	6.7	....			
Baltimore	123	100	113	29.93	30.06	— .05	33.6	— 1.0	58	23	41	8	14	26	31	29	22	66	3.21	— 0.4	9	5,759	n.	27	sw.	27	7	8	14	6.3	5.7	....			
Washington	112	62	85	29.93	30.06	— .05	34.2	— 0.3	61	20	42	6	15	26	32	29	23	68	2.84	— 0.7	10	6,578	nw.	42	nw.	27	7	7	15	6.2	4.3	T.			
Lynchburg	681	153	188	29.29	30.05	— .06	38.8	+ 0.6	68	12	49	8	15	29	39	33	27	66	2.92	— 0.7	10	6,408	nw.	37	nw.	18	8	8	13	5.9	3.6	....			
Norfolk	91	170	205	29.95	30.05	— .06	41.1	— 0.7	75	1	50	17	15	32	43	35	29	68	4.03	+ 0.2	11	11,057	n.	50	nw.	19	11	9	9	5.1	6.4	....			
Richmond	144	11	52	29.90	30.06	— .05	38.8	— 1.1	69	12	49	8	15	28	41	33	26	67	3.68	+ 0.5	10	7,097	s.	37	sw.	20	7	10	12	5.9	1.9	....			
Wytheville	2,293	49	55	27.62	30.09	— .03	34.0	— 1.1	63	12	44	8	14	24	41	30	26	78	3.16	— 1.1	11	6,253	w.	40	nw.	18	12	5	12	5.3	4.6	0.5			
South Atlantic States.							**48.1**	**+ 0.4**										**3.26**	**— 0.9**	**72**													**4.1**		
Asheville	2,255	70	84	27.68	30.11	— .02	37.9	— 0.6	69	12	48	14	15	27	35	32	27	71	3.73	— 1.1	10	7,568	nw.	39	nw.	19	13	7	9	4.8	4.6	1.0			
Charlotte	773	153	161	29.22	30.07	— .05	43.6	— 0.5	68	18	53	14	15	34	38	33	72	5.87	+ 1.4	7	8,567	ne.	48	nw.	18	15	6	8	4.1	3.0	....			
Hatteras	11	12	50	30.03	30.04	— .07	47.2	+ 0.6	69	2	54	29	15	40	33	43	40	80	5.05	+ 0.4	13	12,592	sw.	54	n.	14	13	7	9	5.4	0.4	....			
Manteo	12	4	46	.....	.....	.....	44.9	.....	73	13	55	25	15	35	.....	.....	.....	....	4.26	— 0.1	9	.....	sw.	.....	.....	.....	10	11	8	....	4.0	....			
Raleigh	376	103	110	29.66	30.07	— .04	42.3	— 1.0	70	18	53	9	15	32	43	36	30	68	2.76	— 1.7	10	6,689	sw.	36	nw.	18	11	9	9	5.1	3.7	T.			
Wilmington	78	81	91	29.99	30.08	— .04	48.0	+ 0.3	74	1	58	15	15	38	43	42	38	76	2.64	— 0.8	11	6,032	w.	27	sw.	2	14	6	9	4.0	.....	....			
Charleston	48	11	92	30.04	30.09	— .03	52.0	+ 0.3	76	1	61	22	15	43	30	46	41	73	1.47	— 2.0	8	8,395	sw.	34	n.	13	19	7	3	2.8	.....	....			
Columbia, S. C	351	41	57	29.70	30.10	— .01	49.2	+ 1.4	74	18	60	18	15	39	33	41	35	68	3.76	— 1.0	10	5,662	n.	30	w.	18	19	2	8	3.5	T.	....			
Augusta	180	89	97	29.90	30.10	— .02	50.4	+ 1.4	74	12	60	23	15	40	32	44	39	73	4.28	— 0.2	8	5,534	w.	38	nw.	26	16	5	8	3.8	.....	....			
Savannah	65	150	194	30.03	30.10	— .02	53.8	+ 1.3	78	1	63	24	15	44	29	46	40	69	1.85	— 1.6	6	9,352	nw.	48	nw.	26	17	4	8	3.9	.....	....			
Jacksonville	43	209	245	30.07	30.12	.00	57.2	+ 0.3	79	1	67	28	15	48	28	49	44	70	0.19	— 3.3	4	9,683	sw.	50	w.	25	14	11	4	3.9	.....	....			
Florida Peninsula.							**65.7**	**— 1.2**										**1.65**	**— 1.0**	**76**													**3.5**		
Key West	22	10	64	30.07	30.09	+ .02	69.6	— 1.2	82	2	75	52	15	64	19	63	60	76	0.42	— 1.3	4	7,474	ne.	37	n.	3	19	5	5	3.3	.....	....			
Miami	25	71	79	30.07	30.10	.....	65.7	— 3.1	78	2	74	43	15	58	25	60	56	77	3.69	+ 0.9	6	6,553	nw.	30	w.	26	14	7	8	4.1	.....	....			
Sand Key	23	39	72	30.04	30.07	.00	69.4	.....	78	29	72	53	15	66	14	65	62	80	1.26	.....	6	11,157	ne.	46	n.	3	16	9	4	3.6	.....	....			
Tampa	35	79	96	30.08	30.12	+ .02	61.7	+ 0.8	80	1	71	36	15	52	30	53	48	70	0.85	— 2.5	3	5,283	ne.	31	sw.	25	21	5	3	3.2	.....	....			
East Gulf States.							**49.7**	**— 1.1**										**2.96**	**— 2.0**	**70**													**4.5**		
Atlanta	1,174	190	216	28.86	30.12	.00	44.1	— 1.1	69	12	53	19	3	35	25	38	33	69	3.19	— 1.6	8	10,402	nw.	50	nw.	13	13	4	12	4.6	T.	....			
Macon	370	78	87	29.72	30.12	.00	48.6	— 0.3	75	12	60	24	15	37	36	42	36	70	3.76	— 1.0	7	5,047	nw.	30	nw.	18	14	8	7	4.1	.....	....			
Thomasville	273	49	58	29.82	30.12	.00	54.4	— 0.6	77	12	66	27	3	43	38	46	40	68	1.88	— 2.7	7	4,155	nw.	22	nw.	25	12	9	8	4.8	.....	....			
Pensacola	56	140	182	30.09	30.16	+ .05	53.9	— 1.6	74	9	62	23	3	45	31	48	42	70	2.17	— 2.5	7	9,088	n.	41	nw.	23	13	6	10	4.2	.....	....			
Anniston	741	9	57	29.35	30.16	+ .04	44.2	— 1.6	71	12	56	18	3	33	38	.....	.....	....	4.04	— 0.7	9	4,897	nw.	32	nw.	26	15	4	10	4.5	.....	....			
Birmingham	700	11	48	29.39	30.18	+ .06	45.6	— 2.7	72	12	56	17	3	35	34	38	31	65	3.23	— 1.7	9	5,255	n.	30	nw.	26	13	6	10	5.0	T.	....			
Mobile	57	125	161	30.09	30.15	+ .04	53.0	— 0.2	77	9	63	23	3	43	33	46	42	72	3.20	— 2.3	6	7,657	n.	37	nw.	13	12	14	3	4.3	.....	....			
Montgomery	223	100	112	29.91	30.17	+ .05	49.8	— 1.5	74	9	61	21	3	39	30	42	36	64	4.84	— 0.8	9	5,538	n.	29	nw.	26	15	5	9	4.1	.....	....			
Meridian	375	85	93	29.97	30 18	+ .07	48.0	— 1.1	74	12	60	19	3	36	36	41	36	71	2.38	— 2.7	7	5,227	n.	26	w.	26	13	5	11	5.0	T.	....			
Vicksburg	247	65	74	29.92	30.21	+ .11	49.0	— 1.9	72	17	57	22	3	41	32	43	37	69	1.09	— 3.7	5	5,158	n.	22	nw.	13	13	4	12	5.2	0.5	....			
New Orleans	51	76	84	30.11	30.17	+ .09	56.6	+ 0.3	80	12	66	30	3	47	29	51	47	78	2.76	— 1.8	5	5,224	ne.	25	n.	2	16	7	6	3.8	.....	....			
West Gulf States.							**51.2**	**+ 1.5**										**0.58**	**— 2.3**	**69**													**4.6**		
Shreveport	249	77	93	29.92	30.20	+ .11	50.6	+ 0.6	77	12	60	23	2	41	32	44	38	67	0.01	— 3.7	1	5,685	nw.	23	nw.	12	14	4	11	4.6	T.	....			
Bentonville	1,303	11	44	28.78	30.19	+ .09	37.2	— 1.3	72	21	47	8	2	27	37	.....	.....	....	1.74	— 0.9	5	4,319	nw.	26	sw.	22	15	2	12	.....	.....	....			
Fort Smith	457	79	94	29.69	30.19	+ .09	42.0	+ 0.2	76	21	51	15	2	33	37	37	31	71	1.37	— 1.4	5	6,144	e.	28	nw.	26	15	2	12	4.6	1.5	....			
Little Rock	357	139	147	29.81	30.20	+ .09	44.0	— 0.1	78	17	53	16	2	35	34	39	34	74	2.05	— 2.3	6	7,262	nw.	38	s.	12	15	4	10	4.5	1.9	T.			
Brownsville	57	3	40	.....	.....	.....	64.8	.....	89	23	76	30	2	53	34	.....	.....	....	0.08	.....	5	.....	s.	.....	.....	.....	.....	.....	.....	.....	.....	.....			
Corpus Christi	20	69	77	30.14	30.16	+ .11	60.4	+ 2.7	87	28	68	29	2	53	26	55	52	81	0.07	— 2.0	2	7,612	se.	42	se.	27	6	16	7	5.5	.....	....			
Dallas	512	109	117	29.64	30.21	.....	48.4	.....	82	22	59	18	2	38	36	.....	.....	....	T.	.....	.....	6,585	nw.	34	s.	22	11	9	9	4.9	T.	....			
Fort Worth	670	106	114	29.44	30.17	+ .10	48.8	+ 0.7	82	22	60	18	2	37	41	41	33	60	0.01	— 1.3	1	7,316	nw.	30	nw.	12	10	8	11	5.1	.....	....			
Galveston	54	106	114	30.12	30.18	+ .11	58.3	+ 2.7	75	23	64	30	2	52	22	53	49	78	0.19	— 3.0	3	8,059	s.	35	n.	1	12	9	8	4.4	.....	....			
Houston	138	111	121	30.03	30.19	.....	58.0	+ 4.0	80	12	68	26	2	48	29	.....	.....	....	0.03	.....	3	5,901	se.	25	se.	5	11	12	6	4.5	.....	....			
Palestine	510	64	72	29.63	30.17	+ .09	52.5	+ 1.6	77	17	63	20	2	42	35	45	39	67	0.13	— 3.4	2	5,835	n.	26	nw.	12	13	7	9	4.6	.....	....			
San Antonio	701	109	132	29.41	30.14	+ .09	58.6	+ 4.2	90	28	71	25	2	46	37	49	39	57	0.01	— 1.9	1	5,903	ne.	34	ne.	12	12	12	5	3.9	.....	....			
Taylor	582	55	63	29.59	30.21	+ .15	53.3	+ 2.0	85	28	66	20	2	40	40	.....	.....	....	T.	— 2.7	0	6,650	n.	35	n.	12	15	8	6	3.9	.....	....			

TABLE 1.—*Climatological data for United States Weather Bureau stations, February, 1916*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.							Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea-level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.						Total.	Departure from normal.	Days with 0.01 or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
Ohio Valley and Tennessee.	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles.*						*0–10*	*In.*	*In.*
							33.1	— 2.6										75	2.26	— 1.3								6.5		
Chattanooga	762	189	213	29.34	30.17	+ .04	42.4	— 1.3	71	17	52	15	3	32	41	36	29	65	2.63	— 2.5	7	7,195	nw.	39	nw.	26	11	6	12	5.3	7.5	3.2
Knoxville	996	93	100	29.05	30.14	+ .02	40.0	— 0.8	69	12	50	16	14	30	39	34	28	69	3.33	— 1.8	8	4,250	n.	27	sw.	18	10	7	12	5.6	4.1	T.
Memphis	399	76	97	29.78	30.22	+ .11	42.5	— 0.8	71	17	50	20	2	35	29	38	32	69	2.27	— 2.2	7	7,046	n.	44	nw.	26	14	4	11	4.6	1.0	0.5
Nashville	546	168	191	29.59	30.19	+ .07	39.1	— 2.0	71	17	48	15	3	30	36	34	28	70	1.19	— 3.3	9	7,968	nw.	48	nw.	26	10	8	11	5.5	3.4	1.0
Lexington	989	193	230	29.05	30.16	+ .05	32.8	— 2.8	63	22	42	2	14	24	32				3.40	+ 0.1	11	9,865	sw.	44	nw.	26	8	4	17	6.6	7.1	
Louisville	525	219	255	29.58	30.19	+ .08	33.9	— 2.7	67	22	42	11	14	26	29	30	25	70	3.14	— 0.7	10	9,498	nw.	48	nw.	26	10	3	16	6.2	2.6	T.
Evansville	431	139	175	29.70	30.18	+ .07	34.3	— 1.5	64	22	42	13	8	27	26	31	28	78	1.64	— 1.5	8	8,407	nw.	40	w.	26	7	9	13	6.1	1.0	
Indianapolis	822	194	230	29.25	30.17	+ .07	28.0	— 2.7	65	22	36	0	7	20	30	25	21	77	1.16	— 2.0	5	8,847	nw.	42	nw.	18	5	7	17	6.9	5.0	
Terre Haute	575	96	129	29.53	30.18		29.0		64	22	37	0	7	21	31	26	22	78	1.15		6	7,390	nw.	36	nw.	26	4	15	10	6.7	7.7	
Cincinnati	628	11	51	29.45	30.16	+ .06	29.6	— 4.8	65	22	38	3	14	21	33	26	23	79	1.73	— 1.6	8	6,254	sw.	32	w.	18	7	9	13	6.3	4.8	
Columbus	824	173	222	29.23	30.14	+ .05	26.8	— 4.2	58	22	34	0	8	19	31	24	21	78	1.47	— 1.7	8	8,829	nw.	44	nw.	18	4	10	15	7.3	7.1	
Dayton	899	181	216	29.13	30.13		27.6	— 2.4	60	22	35	2	7	20	28	25	21	79	1.42	— 1.7	9	8,134	nw.	40	nw.	18	4	10	15	6.8	6.3	
Pittsburgh	842	353	410	29.16	30.10	+ .01	26.8	— 5.0	59	22	35	— 1	14	19	32	24	20	75	2.61	— 0.1	15	8,883	nw.	44	nw.	27	4	4	21	7.9	11.9	3.5
Elkins	1,940	41	50	27.97	30.12	+ .02	29.4	— 2.1	63	22	39	— 6	14	20	41	26	22	80	4.02	+ 0.7	16	3,533	nw.	26	w.	27	3	4	22	8.3	17.3	2.0
Parkersburg	638	77	84	29.46	30.14	+ .04	30.0	— 3.9	64	22	38	0	15	22	36	27	24	81	2.75	— 0.6	14	5,072	nw.	34	nw.	26	4	9	16	7.1	8.9	0.2
Lower Lake Region.							20.3	— 4.3										81	2.47	— 0.1								7.3		
Buffalo	767	247	280	29.19	30.06	.00	18.9	— 5.1	41	22	25	— 1	21	12	27	18	15	82	3.64	+ 0.7	20	13,690	w.	70	w.	7	3	6	20	7.8	36.1	14.8
Canton	448	10	61	29.52	30.03		11.6	— 6.4	40	1	20	—32	14	3	36				4.12	+ 1.5	19	8,322	w.	44	w.	7	9	11	9	5.5	22.9	12.0
Oswego	335	76	91	29.65	30.04	— .02	18.8	— 5.1	38	1	25	— 6	21	13	33	18	15	84	2.32	— 0.3	20	9,692	nw.	48	sw.	7	0	7	22	8.6	26.7	12.5
Rochester	523	97	113	29.46	30.06	.00	19.2	— 4.7	41	22	25	0	21	13	30	18	14	77	3.76	+ 0.8	17	7,644	w.	45	w.	7	0	11	18	8.1	35.7	18.0
Syracuse	597	97	113	29.37	30.04	— .03	18.3	— 5.5	41	22	25	—11	14	12	29	17	14	83	3.93	+ 2.0	21	8,966	w.	52	nw.	18	4	9	16	7.3	27.2	13.7
Erie	714	130	166	29.28	30.08	+ .01	20.7	— 5.4	50	22	27	— 2	14	14	29	19	17	83	2.74	— 0.2	20	10,035	w.	48	w.	7	4	7	18	7.3	26.4	8.0
Cleveland	762	190	201	29.26	30.11	+ .04	23.0	— 3.8	54	22	30	1	8	16	30	20	16	76	1.52	— 1.2	16	10,448	w.	47	nw.	7	4	5	20	7.6	13.2	2.0
Sandusky	629	62	103	29.41	30.12	+ .05	23.6	— 3.5	54	22	30	1	8	17	29	22	18	79	1.07	— 1.4	12	9,935	w.	48	n.	18	2	10	17	7.5	7.6	
Toledo	628	208	243	29.42	30.13	+ .06	24.0	— 2.8	55	22	31	3	14	17	29	22	18	79	0.62	— 1.4	10	10,468	sw.	46	w.	7	6	8	15	6.7	2.9	
Fort Wayne	856	113	124	29.19	30.16		24.1	— 1.7	56	22	32	1	7	17	28	22	19	81	0.45		5	7,320	sw.	34	nw.	18	4	8	17	7.0	3.9	
Detroit	730	218	245	29.29	30.12	+ .06	21.6	— 3.4	46	22	28	4	21	15	27	20	17	83	0.97	— 1.3	16	8,378	w.	38	n.	18	6	7	16	6.9	8.8	T.
Upper Lake Region.							16.1	— 3.0										81	0.82	— 1.0								7.5		
Alpena	609	13	92	29.40	30.10	+ .07	15.7	— 2.1	44	17	23	— 9	21	9	31	14	12	84	0.86	— 1.0	15	8,235	nw.	47	nw.	26	4	13	12	6.7	13.2	2.6
Escanaba	612	54	60	29.43	30.14	+ .08	12.6	— 2.7	46	17	21	—14	14	4	32	10	6	77	0.63	— 0.8	11	6,539	n.	30	n.	18	8	13	8	5.3	7.8	2.0
Grand Haven	632	54	92	29.42	30.14	+ .09	21.5	— 2.7	39	17	27	— 3	14	16	31	20	16	80	0.80	— 1.2	18	8,766	w.	45	w.	7	3	6	20	7.7	9.2	1.3
Grand Rapids	707	70	87	29.34	30.14	+ .09	21.1	— 4.4	43	17	27	— 6	14	15	30	19	16	82	0.74	— 1.2	16	4,989	w.	28	nw.	26	2	7	20	8.2	13.3	1.0
Houghton	684	62	72	29.36	30.13	+ .08	10.7	— 5.3	42	17	18	—11	28	3	42				1.07	— 0.7	17	6,255	w.	32	n.	26	3	8	18	8.0	12.5	24.4
Lansing	878	11	62	29.14	30.12		19.2	— 2.4	43	22	27	—14	14	12	34	17	14	83	0.69	— 1.4	19	5,116	w.	26	nw	26	4	5	20	7.6	9.1	T.
Ludington	637	60	66	29.40	30.13		19.8		40	17	25	4	21	15	29	18	15	83	1.28		18	8,068	w.	37	nw.	7	0	4	25	8.9	14.8	2.9
Marquette	734	77	111	29.31	30.15	+ .10	13.9	— 2.0	54	16	21	— 7	1	6	31	11	6	75	1.34	— 0.5	15	8,252	nw.	35	nw.	26	2	12	15	7.0	14.2	25.0
Port Huron	638	70	120	29.38	30.10	+ .05	18.6	— 3.4	42	22	25	1	8	12	27	17	15	84	1.09	— 1.1	14	8,294	nw.	40	nw.	27	3	12	14	6.7	13.1	1.5
Saginaw	641	48	82	29.39	30.12		17.4		42	17	25	—15	14	10	33	17	15	90	0.85	— 1.3	9	6,721	w.	36	nw.	26	5	6	18	7.6	9.6	1.2
Sault Sainte Marie	614	11	61	29.37	30.12	+ .09	11.4	— 2.0	41	17	19	—16	21	3	41	9	5	80	0.57	— 0.9	11	6,777	nw.	42	nw.	26	3	14	12	6.7	6.0	17.8
Chicago	823	140	310	29.25	30.18	+ .10	25.0	— 0.4	50	22	31	— 3	7	19	23	22	17	71	0.87	— 1.4	9	8,536	w.	31	nw.	18	10	5	14	5.9	8.0	
Green Bay	617	109	144	29.45	30.15	+ .09	13.6	— 3.6	42	17	21	—12	2	6	31	18	7	77	1.09	— 0.6	9	7,744	sw.	42	n.	18	6	7	16	6.9	13.3	1.5
Milwaukee	681	119	133	29.39	30.16	+ .10	19.6	— 2.3	44	17	26	— 8	7	13	29	18	15	84	0.47	— 1.5	8	7,159	nw.	32	ne.	18	9	10	10	5.4	5.7	T.
Duluth	1,133	11	47	28.89	30.19	+ .11	7.0	— 6.6	45	17	16	—24	2	—2	27	5	2	84	0.36	— 0.7	9	9,246	w.	48	nw.	24	12	11	6	4.6	4.8	1.1
North Dakota.							6.8	— 0.2										85	0.40	— 0.2								4.2		
Moorhead	940	8	57	29.19	30.28	+ .17	4.8	— 2.2	40	16	16	—30	13	—6	37	3	0	83	0.51	— 0.2	8	6,130	nw.	36	nw.	6	20	6	3	2.8	5.1	7.1
Bismarck	1,674	8	57	28.39	30.29	+ .17	11.8	+ 3.5	50	23	21	—25	7	2	34	9	6	82	0.39	— 0.1	7	6,898	nw.	44	nw.	25	13	9	7	4.1	4.4	1.5
Devils Lake	1,482	11	44	28.55	30.23	+ .12	3.2	— 1.3	39	16	12	—29	7	—6	31	2	0	89	0.32	— 0.2	6	7,725	w.	40	w.	6	11	12	6	4.8	4.0	1.3
Williston	1,872	40	47	28.15	30.26	+ .15	7.2	— 0.7	45	15	16	—25	7	—2	43	6	4	86	0.39	— 0.1	8	4,480	nw.	36	nw.	23	13	4	12	5.2	4.2	1.5
Upper Mississippi Valley.							23.0	— 1.6										80	0.66	— 1.1								5.7		
Minneapolis	918	10	208	29.16	30.20		11.0		47	17	19	—20	2	3	27				0.32	—0.4	10	7,396	nw.	34	nw.	17	8	7	14	5.9	7.3	7.1
St. Paul	837	201	236	29.26	30.22	+.13	11.5	—3.5	47	17	20	—20	2	3	26				0.39	—0.5	12	7,393	nw.	37	nw.	24	8	12	9	5.2	5.4	9.0
La Crosse	714	11	48	29.38	30.20	+.12	17.5	—0.9	51	17	25	—13	7	10	33				0.90	—0.2	8	3,902	nw.	22	nw.	6	10	6	13	5.8	12.4	
Madison	974	70	78	29.09	30.20	+.13	17.1	—2.5	45	17	24	—12	7	10	26	14	10	76	0.39	—1.2	7	6,375	nw.	29	nw.	18	6	8	15	6.6	6.0	T.
Charles City	1,015	10	49	29.08	30.22	+.12	14.8	—0.3	45	17	23	—20	7	7	29	13	11	88	0.50	—0.5	6	4,707	nw.	24	s.	14	8	12	9	5.8	11.0	T.
Davenport	606	71	79	29.52	30.22	+.12	22.3	—1.5	54	22	30	— 9	7	15	29	20	16	80	0.37	—1.2	3	5,063	w.	24	nw.	7	11	6	12	5.4	4.3	
Des Moines	861	84	97	29.27	30.22	+.11	21.3	—2.8	54	19	30	— 8	2	13	34	19	16	82	0.61	—0.5	6	5,254	nw.	28	nw.	26	6	12	11	6.0	5.6	0.1
Dubuque	698	81	96	29.44	30.23	+.14	20.1	—1.5	47	17	28	—10	7	13	31	17	14	80	0.76	—0.7	10	4,557	nw.	25	nw.	6	8	10	11	5.6	7.4	0.2
Keokuk	614	64	78	29.51	30.23	+.12	25.5	—1.1	60	22	34	— 4	7	17	31	23	20	82	0.59	—1.1	7	5,398	nw.	29	nw.	26	11	9	9	4.6	5.0	
Cairo	356	87	93	29.79	30.18	+.06	37.2	—0.4	67	17	45	16	2	30	27	33	28	73	0.83	—2.6	7	7,382	nw.	39	nw.	26	10	7	12	5.6	1.3	0.8
Peoria	609	11	45	29.51	30.21	+.11	24.4	—1.5	60	22	32	— 4	7	16	28	22	20	87	0.29	—2.5	7	5,213	nw.	27	w.	5	10	8	11	5.7	3.1	
Springfield, Ill	644	10	91	29.48	30.20	+.10	27.2	—1.9	65	22	35	— 2	8	20	33	24	20	77	1.00	—1.9	7	6,332	nw.	32	nw.	26	9	6	14	6.2	7.4	
Hannibal	534	74	109	29.61	30.22	+.11	27.4	—1.7	60	22	35	1	7	19	30				0.53	—1.1	5	6,389	nw.	33	nw.	26	10	10	9	5.1	8.2	T.
St. Louis	567	265	303	29.57	30.20	+.09	32.8	—0.7	68	22	41	7	7	25	30	29	25	77	1.78	—1.1	7	8,609	nw.	41	nw.	26	9	8	12	5.9	5.7	T.
Missouri Valley.							25.0	+ 0.6										81	0.49	— 0.6								4.7		
Columbia, Mo	781	11	84	29.34	30.20	+ .09	29.8	— 0.3	63	22	38	5	2	21	28				0.81	— 1.4	7	6,126	nw.	42	nw.	26	8	8	13	6.0	7.1	
Kansas City	963	161	181	29.15	30.22	+ .11	30.2	+ 0.3	62	16	38	2	2	22	30	27	23	76	0.57	— 1.1	5	8,257	n.	44	nw.	26	16	5	8	4.1	6.0	T.
St. Joseph	967	11	49	29.15	30.23		27.0		58	19	35	— 4	2	19	29	24	20	80	0.47		3	5,852	nw.	37	nw.	26	12	8	9	4.7	4.7	T.
Springfield, Mo	1,324	98	104	28.75	30.20	+ .09	34.0	+ 0.4	71	21	42	5	2	26	34	31	27	79	0.57	— 1.8	9	7,382	nw.	34	nw.	26	15	6	8	4.0	3.2	T.
Iola	984	11	50	29.14	30.23	+ .13	32.2	+ 0.2	71	21	42	4	1	22	40				0.97	— 0.2	5	5,012	n.	30	n.	12	15	5	9	4.0	3.5	2.0
Topeka	983	85	101				29.4	— 0.6	61	21	39	— 3	2	20	34				0.31	— 1.1	4	6,185	nw.	34	nw.	26	15	4	10	4.4	5.2	T.
Drexel	1,299	10	53	28.79	30.25		21.4		56	21	30	—15	2	13	30	19	17	89	0.48		3	6,824	nw.	31	nw.	26	9	11	9	5.2	4.6	0.8
Lincoln	1,189	11	84	28.92	30.24	+ .14	24.2	— 0.6	62	19	34	—15	2	15	32	22	19	84	0.35	— 0.4	4	6,364	n.	42	nw.	26	13	8	8	4.4	6.2	T.
Omaha	1,105	115	121	29.01	30.25	+ .14	23.6	— 0.1	58	19	31	— 7	2	16	29	21	17	78	0.54	— 0.2	6	6,242	nw.	36	nw.	25	14	8	7	4.7	5.9	T.
Valentine	2,598	47	54	27.40	30.24	+ .15	23.8	+ 2.6	65	20	36	—21	2	12	37	20	16	80	0.27	— 0.4	7	5,859	w.	38	nw.	25	15	7	7	4.6	1.9	0.8
Sioux City	1,135	94	164	28.97	30.25	+ .13	19.5	— 0.3	61	19	28	—20	2	11	32	17	14	82	0.36	— 0.2	5	8,045	nw.	44	nw.	26	15	10	4	3.7	4.6	T.
Huron	1,306	59	74	28.81	30.28	+ .16	13.7	+ 0.8	46	23	22	—22	2	5	34	12	10	85	0.55	+ 0.1	9	7,221	nw.	39	nw.	25	11	9	9	5.1	4.7	0.2
Pierre	1,572	70	75	28.53	30.29	+ .18	19.2	+ 2.3	59	19	29	—21	13	10	42	16	12	78	0.31	— 0.2	7	6,141	nw.	44	nw.	25	7	11	11	5.7	3.1	T.
Yankton	1,233	49	57	28.87	30.26	+ .14	20.4	+ 2.2	59	19	29	—18	2	12	32				0.29	— 0.3	5	5,776	nw.	33	nw.	25	12	10	7	5.0	4.1	T.

TABLE I.—*Climatological data for United States Weather Bureau stations, February, 1916*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.											Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea-level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with 0.01 or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*		°*F.*	°*F.*		°*F.*	°*F.*	°*F.*	°*F.*			%	*In.*	*In.*		*Miles.*								*0–10*	*In.*	*In.*
Northern Slope.							**23.9**	**+ 2.4**												**72**	**0.59**	**− 0.2**									**5.1**		
Havre	2,505	11	44	27.48	30.26	+ .19	14.2	− 0.8	49	15	23	−28	3	6	56	13	11	84	0.47	0.0	7	5,605	w.	36	sw.	13	7	13	9	5.8	4.7	0.3
Helena	4,110	87	114	25.87	30.23	+ .12	24.2	+ 2.0	53	14	34	− 9	1	15	36	21	17	76	1.06	+ 0.3	10	4,408	sw.	36	w.	11	8	11	10	5.8	15.5	2.0
Kalispell	2,962	11	34	27.02	30.20	+ .12	24.4	+ 0.6	48	17	32	−16	1	17	25	23	20	82	1.06	− 0.4	8	2,532	w.	26	sw.	7	3	9	17	7.6	8.0	1.4
Miles City	2,371	26	48	27.62	30.30	+ .21	18.0	+ 1.2	50	17	28	−28	2	8	38	16	12	82	0.18	− 0.4	4	3,443	ne.	28	w.	25	9	13	7	5.3	2.0	0.3
Rapid City	3,259	50	58	26.68	30.26	+ .18	25.8	+ 2.3	66	19	38	−13	2	13	51	20	13	60	0.44	0.0	4	6,242	n.	37	n.	7	11	10	8	4.8	2.9	1.4
Cheyenne	6,088	84	101	24.02	30.14	+ .11	31.8	+ 5.5	64	16	44	− 4	3	20	39	25	16	54	0.30	− 0.3	5	9,770	w.	60	w.	7	11	10	8	4.7	3.8	0.4
Lander	5,372	60	68	24.68	30.24	+ .16	23.6	+ 1.8	59	10	37	−23	1	11	46	18	12	65	0.40	− 0.3	3	2,769	e.	56	w.	7	12	15	2	3.8	4.9	1.2
Sheridan	3,790	10	47	26.17	30.24	.....	22.0	.....	58	19	35	−17	4	9	43	18	14	76	1.17	.....	6	3,115	nw.	36	sw.	8	12	12	5	4.2	14.3	7.0
Yellowstone Park	6,200	11	48	23.88	30.20	+ .10	24.4	+ 4.8	49	15	36	− 9	3	13	34	21	16	69	0.59	− 1.3	11	5,990	s.	34	s.	10	10	11	8	5.0	4.2	8.4
North Platte	2,821	11	51	27.20	30.24	+ .17	28.8	+ 4.2	69	21	41	−11	1	16	43	23	18	72	0.81	+ 0.4	4	4,337	w.	28	n.	17	17	7	5	3.6	8.2	0.1
Middle Slope.							**34.7**	**+ 2.3**												**68**	**0.17**	**− 0.6**									**3.8**		
Denver	5,292	106	113	24.76	30.14	+ .13	36.5	+ 5.4	65	11	49	− 4	1	24	48	28	18	51	0.03	− 0.5	2	4,809	se.	33	nw.	24	13	15	1	3.4	1.9	....
Pueblo	4,685	80	86	25.34	30.14	+ .14	36.0	+ 4.2	70	16	53	−14	1	19	52	28	18	54	T.	− 0.5	0	4,139	nw.	32	w.	29	20	8	1	2.4	T.	....
Concordia	1,392	50	58	28.72	30.25	+ .16	28.2	− 0.6	66	19	38	− 5	2	19	34	24	21	80	0.41	− 0.4	3	4,972	nw.	29	nw.	26	12	8	9	4.9	4.1	0.3
Dodge	2,509	11	51	27.53	30.23	+ .17	34.9	+ 3.8	74	16	49	− 7	1	21	48	27	21	68	0.06	− 0.7	2	6,228	n.	35	se.	29	15	9	5	3.7	0.6	....
Wichita	1,358	139	158	28.72	30.20	+ .12	33.4	+ 0.4	71	21	43	1	1	24	32	30	26	77	0.13	− 1.0	4	7,898	n.	34	n.	12	15	6	8	3.7	1.2	T.
Oklahoma	1,214	10	47	28.88	30.20	+ .13	39.3	+ 0.8	74	20	49	10	1	29	36	34	30	76	0.39	− 0.6	4	9,577	n.	44	n.	12	14	5	10	4.4	T.	....
Southern Slope.							**50.1**	**+ 5.6**												**48**	**0.01**	**− 0.9**									**3.2**		
Abilene	1,738	10	52	28.30	30.14	+ .09	50.0	+ 5.2	83	11	66	11	2	34	51	39	27	50	0.01	− 1.1	1	7,199	s.	33	s.	4	14	10	5	3.9	.....	.....
Amarillo	3,676	10	49	26.33	30.13	+ .11	43.5	+ 6.3	81	11	60	9	1	27	54	33	25	58	0.02	− 0.9	1	7,022	ne.	32	ne.	12	24	5	0	2.5	0.2	....
Del Rio	944	64	71	29.14	30.14	+ .14	58.4	+ 4.8	91	28	71	21	2	46	41	.....	.....	.....	0.01	− 0.9	1	6,157	se.	38	n.	12	15	13	1	3.6	.....	.....
Roswell	3,566	75	85	26.44	30.09	+ .11	48.4	+ 5.9	80	11	65	12	2	32	47	36	19	37	T.	− 0.6	0	5,289	s.	35	w.	28	19	9	1	2.8	.....	.....
Southern Plateau.							**46.8**	**+ 1.9**												**47**	**0.18**	**− 0.5**									**3.0**		
El Paso	3,762	110	133	26.27	30.06	+ .11	53.4	+ 4.5	80	11	67	18	2	40	39	40	24	36	0.02	− 0.4	1	7,002	w.	44	w.	28	17	9	3	3.1	T.	....
Sante Fe	7,013	57	66	23.30	30.13	+ .15	36.9	+ 4.9	57	11	47	− 2	1	26	26	29	21	57	0.20	− 0.7	3	5,320	ne.	34	n.	6	16	9	4	3.6	1.3	T.
Flagstaff	6,908	8	57	23.40	30.11	+ .11	31.8	+ 1.0	58	10	45	− 8	2	18	48	.....	.....	.....	0.77	.....	5	.....	w.	32	w.	28	13	9	7	.....	1.8	2.0
Phoenix	1,108	76	81	28.88	30.04	+ .05	59.6	+ 5.2	82	15	73	29	2	46	35	49	38	51	0.13	− 0.6	2	3,233	e.	21	sw.	21	15	9	5	3.8	.....	.....
Yuma	141	9	54	29.89	30.04	+ .04	64.1	+ 4.9	86	17	77	35	2	51	34	51	39	45	T.	− 0.6	0	4,045	n.	23	n.	15	23	5	1	1.7	.....	.....
Independence	3,910	11	42	26.07	30.14	+ .08	34.8	− 8.9	60	27	47	2	1	22	30	.....	.....	.....	0.57	− 0.2	4	2,789	n.	35	w.	29	8	14	7	.....	.....	.....
Middle Plateau.							**36.5**	**+ 3.5**												**72**	**0.74**	**− 0.4**									**5.2**		
Reno	4,532	74	81	25.53	30.13	+ .05	41.0	+ 5.4	61	16	52	4	1	30	32	35	29	65	0.59	− 1.3	6	3,719	w.	33	w.	29	9	10	10	5.2	0.6	....
Tonopah	6,090	12	20	24.12	30.15	.....	36.4	.....	54	16	43	9	1	30	22	32	27	69	0.28	− 0.5	4	4,707	se.	30	nw.	27	12	8	9	4.9	1.1	0.3
Winnemucca	4,344	18	56	25.69	30.14	+ .05	37.4	+ 4.1	57	20	48	6	1	27	30	34	29	74	1.44	+ 0.5	10	5,257	ne.	25	sw.	28	11	5	13	5.6	5.6	0.1
Modena	5,479	10	43	24.69	30.12	+ .08	36.1	+ 4.5	59	11	48	− 8	1	24	36	31	25	69	0.52	− 0.7	5	5,863	sw.	40	sw.	27	12	13	4	4.1	0.3	....
Salt Lake City	4,360	147	189	25.72	30.19	+ .11	36.0	+ 3.1	55	9	42	13	2	30	24	32	29	78	1.18	− 0.3	8	3,828	nw	36	nw.	27	7	4	18	7.0	6.5	T.
Grand Junction	4,602	82	96	25.51	30.20	+ .16	31.9	+ 0.4	54	24	43	− 9	1	21	30	28	24	79	0.45	− 0.2	6	3,193	nw.	34	nw.	29	10	12	7	4.6	1.5	0.2
Northern Plateau.							**33.9**	**+ 1.8**												**77**	**2.26**	**+ 0.8**									**6.8**		
Baker	3,471	48	53	26.52	30.19	+ .07	31.6	+ 3.7	52	10	39	4	4	24	22	29	26	79	1.91	+ 0.5	7	4,262	se.	27	sw.	10	9	7	13	5.8	15.8	....
Boise	2,739	78	86	27.28	30.20	+ .08	38.6	+ 4.8	54	10	46	21	1	31	23	35	30	73	3.21	+ 1.8	12	3,160	se.	20	se.	10	10	4	15	6.2	23.7	....
Lewiston	757	40	48	29.35	30.19	+ .08	34.7	− 1.5	52	15	41	4	4	28	20	.....	.....	.....	2.48	+ 1.1	15	2,249	e.	28	sw.	28	3	8	18	7.5	27.2	....
Pocatello	4,477	46	54	25.56	30.19	+ .09	32.6	+ 4.5	54	10	41	6	28	24	26	29	25	75	1.60	+ 0.7	11	4,873	se.	29	se.	2	8	10	11	5.8	16.1	4.5
Spokane	1,929	101	110	28.07	30.18	+ .09	33.1	+ 3.0	53	15	39	8	1	27	25	30	26	75	1.04	− 0.9	11	3,838	ne.	28	sw.	7	4	6	19	7.5	8.0	T.
Walla Walla	991	57	65	29.07	30.17	+ .06	32.6	− 3.8	58	9	37	9	3	28	26	31	28	83	3.34	+ 1.7	11	2,695	s.	26	sw.	28	4	6	19	8.0	33.4	....
North Pacific Coast Region.							**43.8**	**+ 2.5**												**83**	**8.06**	**+ 2.2**									**6.7**		
North Head	211	11	56	29.78	30.02	− .04	45.8	+ 3.7	65	18	50	29	3	42	20	44	42	87	10.55	+ 4.6	17	12,816	e.	62	s.	9	9	4	16	6.5	3.2	
Port Crescent	259	8	53	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Seattle	125	215	250	29.93	30.07	+ .01	41.9	+ 1.4	59	27	48	26	4	36	23	40	36	82	6.85	+ 2.9	15	5,174	se.	54	sw.	10	2	10	17	7.7	35.4	....
Tacoma	213	113	120	29.83	30.06	.00	42.0	+ 1.6	62	18	49	24	4	36	30	40	37	84	7.32	+ 2.0	15	3,874	n.	37	sw.	10	4	7	18	7.5	18.0	....
Tatoosh Island	109	7	57	29.89	29.99	− .01	42.0	+ 1.0	58	26	45	31	2	39	15	40	39	90	10.78	+ 1.8	17	16,734	e.	88	ne.	2	9	4	16	6.4	3.0	....
Portland, Oreg	153	68	106	29.90	30.07	− .01	42.2	+ 0.9	58	27	48	22	4	36	22	39	34	76	7.87	+ 1.9	14	4,872	se.	28	e.	26	8	5	16	6.3	8.2	....
Roseburg	510	9	57	29.51	30.07	− .03	48.8	+ 6.2	70	14	56	31	28	41	25	46	42	79	5.01	+ 0.3	15	1,740	s.	24	se.	9	3	18	8	6.0	.....	.....
Middle Pacific Coast Region.							**52.9**	**+ 3.9**												**79**	**3.31**	**− 1.1**									**6.3**		
Eureka	62	73	89	30.03	30.10	− .01	50.4	+ 3.6	68	17	56	35	29	45	24	48	46	87	5.18	− 2.1	16	3,964	s.	34	se.	9	5	6	18	7.7	.....	.....
Mount Tamalpais	2,375	11	18	27.62	30.11	+ .01	48.4	+ 2.8	65	15	52	36	29	44	15	44	40	76	4.90	− 1.0	16	11,717	ne.	60	s.	10	9	3	17	6.3	.....	.....
Point Reyes Light	490	7	18	29.53	30.05	.....	53.2	+ 4.0	75	15	58	42	2	48	23	.....	.....	.....	2.44	.....	14	10,958	s.	55	s.	4	6	7	16	6.9	.....	.....
Red Bluff	332	50	56	29.73	30.10	− .01	53.6	+ 4.3	77	17	61	36	28	46	30	49	45	74	1.73	− 2.0	11	3,991	se.	25	se.	4	8	6	15	6.3	.....	.....
Sacramento	69	106	117	30.04	30.10	+ .01	53.8	+ 3.6	70	17	61	35	1	47	24	51	47	79	2.45	− 0.8	15	4,520	se.	34	se.	4	10	9	10	5.4	.....	.....
San Francisco	155	209	213	29.93	30.10	.00	55.8	+ 4.5	72	16	62	41	1	50	21	52	49	80	3.77	0.0	15	3,936	n.	28	nw.	29	10	4	15	5.8	.....	.....
San Jose	141	12	110	29.95	30.10	.....	55.2	+ 4.6	75	15	64	31	1	46	33	.....	.....	.....	1.83	− 0.8	9	3,593	se.	25	se.	21	9	6	14	5.8	.....	.....
South Pacific Coast Region.							**56.6**	**+ 4.0**												**76**	**1.63**	**− 0.9**									**5.1**		
Fresno	327	89	98	29.76	30.12	+ .04	54.9	+ 5.7	74	18	64	34	1	46	29	50	46	75	1.67	+ 0.3	8	3,220	e.	31	sw.	25	4	17	8	5.8	.....	.....
Los Angeles	338	159	191	29.72	30.09	+ .03	58.7	+ 4.6	88	15	68	39	1	50	32	52	48	74	1.82	− 1.2	5	3,603	sw.	24	sw.	29	10	12	7	4.7	.....	.....
San Diego	87	62	70	29.99	30.09	+ .03	56.4	+ 1.8	78	15	64	38	1	49	28	51	48	81	0.66	− 1.4	5	3,336	nw.	21	w.	29	13	8	8	4.7	.....	.....
San Luis Obispo	201	32	40	29.90	30.12	+ .01	56.4	+ 3.9	85	15	67	36	1	46	38	51	48	76	2.38	− 1.4	8	2,584	n.	20	ne.	11	11	7	11	5.3	.....	.....
West Indies.																																	
San Juan	82	8	54	29.93	30.02	− .03	74.6	.....	88	25	80	65	7	70	18	.....	.....	.....	1.66	− 0.9	15	9,312	ne.	40	ne.	1	8	18	3	4.9	.....	.....
Panama.																																	
Balboa Heights	118	7	97	29.77	29.89	.....	79.0	.....	90	6	87	68	5	71	22	72	70	84	1.48	+ 0.6	8	7,934	nw.	30	n.	4	4	19	6	5.8	.....	.....
Colon	25	5	71	29.88	29.91	.....	79.8	.....	85	29	84	73	18	76	11	75	73	84	1.96	+ 0.2	22	11,532	n.	33	n.	17	8	15	6	5.0	.....	.....

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during February, 1916, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex	21			0.01														0.01			
Albany, N. Y	24-26			1.70														*			
Alpena, Mich	8			0.16														*			
Amarillo, Tex	1			0.02														*			
Anniston, Ala	1-2			1.66														*			
Asheville, N. C	24			1.62														*			
Atlanta, Ga	23			0.72														.41			
Atlantic City, N. J	1-3			2.26														*			
Augusta, Ga	28-29	7:50 p. m.	D. N. a. m.	1.48	11:30 p. m.	11:55 p. m.	T.	0.41	0.66	0.73	0.81	0.87									
Baker, Oreg	1-3			1.39														*			
Baltimore, Md	2-3			1.38														*			
Bentonville, Ark	22	4:50 p. m.	5:40 p. m.	0.67	5:04 p. m.	5:14 p. m.	0.01	.41	.61												
Binghamton, N. Y	24-26			1.49														.18			
Birmingham, Ala	28			0.79														.49			
Bismarck, N. Dak	10			0.14														*			
Block Island, R. I	24-26			1.64														.25			
Boise, Idaho	1-2			1.59														*			
Boston, Mass	24-26			2.65														.39			
Buffalo, N. Y	6-7			0.56														*			
Burlington, Vt	25-27			1.51														*			
Cairo, Ill	12			0.38														.13			
Canton, N. Y	24-27			3.04														*			
Charles City, Iowa	4			0.33														*			
Charleston, S. C	29			0.92														.63			
Charlotte, N. C	1-2			3.78														.40			
Chattanooga, Tenn	9			0.64														.33			
Cheyenne, Wyo	27			0.14														*			
Chicago, Ill	22			0.31														*			
Cincinnati, Ohio	12			1.11														.21			
Cleveland, Ohio	26-27			0.44														*			
Columbia, Mo	5			0.54														*			
Columbia, S. C	1-3			1.95														.38			
Columbus, Ohio	12			0.64														.21			
Concord, N. H	24-26			2.56														*			
Concordia, Kans	27			0.28														*			
Corpus Christi, Tex	13			0.06														.04			
Davenport, Iowa	4			0.27														*			
Dayton, Ohio	12-13			0.90														*			
Del Rio, Tex	8			0.01														.01			
Denver, Colo	28			0.02														*			
Des Moines, Iowa	4			0.26														*			
Detroit, Mich	8			0.26														*			
Devils Lake, N. Dak	10-11			0.15														*			
Dodge City, Kans	3			0.04														*			
Dubuque, Iowa	4-5			0.39														*			
Duluth, Minn	8			0.11														*			
Eastport, Me	2-3			0.66														*			
Elkins, W. Va	12-13			1.63														.22			
El Paso, Tex	21			0.02														T.			
Erie, Pa	24-27			1.35														*			
Escanaba, Mich	8			0.33														*			
Eureka, Cal	29			1.23														.35			
Evansville, Ind	22-23			0.70														.22			
Flagstaff, Ariz	21			0.30														*			
Fort Smith, Ark	28			0.56														*			
Fort Wayne, Ind	6			0.25														*			
Fort Worth, Tex	22			0.01														.01			
Fresno, Cal	26-29			0.72														.21			
Galveston, Tex	13			0.10														.07			
Grand Haven, Mich	4-5			0.18														*			
Grand Junction, Colo	26-28			0.24														*			
Grand Rapids, Mich	2-5			0.27														*			
Green Bay, Wis	10-11			0.30														*			
Hannibal, Mo	5-6			0.32														*			
Harrisburg, Pa	2-3			1.03														*			
Hartford, Conn	24-26			3.26																	
Hatteras, N. C	9	10:55 a. m.	1:50 p. m.	1.16	12:08 p. m.	12:58 p. m.	0.08	0.09	0.25	0.33	0.45	0.55	0.62	0.70	0.75	0.84	0.90				
Havre, Mont	9			0.16														*			
Helena, Mont	5-6			0.35														*			
Houghton, Mich	1			0.21														*			
Houston, Tex	13, 28, and 29			0.01														.01			
Huron, S. Dak	11-12			0.20														*			
Independence, Cal	21			0.22														.13			
Indianapolis, Ind	12			0.60														*			
Iola, Kans	22			0.55														.43			
Jacksonville, Fla	29			0.15														.09			
Kalispell, Mont	8-10			0.58														*			
Kansas City, Mo	5-6			0.35														*			
Keokuk, Iowa	5-6			0.33														*			
Key West, Fla	7			0.26														.11			
Knoxville, Tenn	1-2			1.34														*			
La Crosse, Wis	4			0.30														*			
Lander, Wyo	27			0.30														*			
Lansing, Mich	2-4			0.18														*			
Lewiston, Idaho																					
Lexington, Ky	11-12			1.09														*			
Lincoln, Nebr	27-28			0.18														*			
Little Rock, Ark	22			0.52														.26			
Los Angeles, Cal	25-27			1.63														.73			
Louisville, Ky	11-13			1.47														.31			
Ludington, Mich	6-8			0.41														*			
Lynchburg, Va	2-3			0.95														.15			
Macon, Ga	9	2:44 p. m.	3:02 p. m.	0.31	2:50 p. m.	2:56 p. m.	.01	.27	.30												
Madison, Wis	4-5			0.28														*			
Marquette, Mich	28-29			0.22														*			
Memphis, Tenn	28			0.81														*			

* Self-register not working.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during February, 1916, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.												
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Meridian, Miss.	28	5:45 p. m.	11:15 p. m.	0.87	7:10 p. m.	7:15 p. m.	.30	.25													
Miami, Fla.	22	D. N. a. m.	D. N. a. m.	1.35	4:25 a. m.	4:41 a. m.	.80	.16	.26	.43	.48										
Milwaukee, Wis.	4–5			0.30														*			
Minneapolis, Minn.	4–5			0.08														*			
Mobile, Ala.	1–2			1.75														*			
Modena, Utah	27			0.25														0.07			
Montgomery, Ala.	28	7:10 p. m.	D. N. p. m.	1.62	9:41 p. m.	10:17 p. m.	.12	.33	.60	.68	.82	.97	1.26	1.35	1.39						
Moorhead, Minn.	9–11			0.36														*			
Mount Tamalpais, Cal.	2–4			2.21														.27			
Nantucket, Mass.	2–3			0.99														.11			
Nashville, Tenn.	9			0.25														.13			
New Haven, Conn.	24–26			2.65														.25			
New Orleans, La.	1	6:30 a. m.	D. N. p. m.	2.37	2:25 p. m.	2:45 p. m.	.06	.15	.37	.63	.82										
					3:19 p. m.	3:44 p. m.	1.04	.07	.25	.38	.48	.62									
New York, N. Y.	24–26			2.16														.35			
Norfolk, Va.	2–3			1.19														*			
Northfield, Vt.	25–26			1.67														*			
North Head, Wash.	[1]31–2			5.25														.34			
North Platte, Nebr.	27–28			0.77														*			
Oklahoma, Okla.	28			0.32														14			
Omaha, Nebr.	4			0.24														*			
Oswego, N. Y.	24–27			1.76														*			
Palestine, Tex.	12			0.12														.12			
Parkersburg, W. Va.	12–13			1.52														.34			
Pensacola, Fla.	9			0.46														.38			
Peoria, Ill.	5–6			0.16														*			
Philadelphia, Pa.	2–3			1.18														*			
Phoenix, Ariz.	21			0.11														.03			
Pierre, S. Dak.	11–12			0.10														*			
Pittsburgh, Pa.	24–25			0.78														*			
Pocatello, Idaho.	27			0.44														*			
Point Reyes Light, Cal.	2–4			1.11														.15			
Port Huron, Mich.	18			0.23														*			
Portland, Me.	25–26			1.65														.22			
Portland, Oreg.	5–10			2.56														.22			
Providence, R. I.	24–26			2.62														*			
Pueblo, Colo.	1, 3, 17			T.														*			
Raleigh, N. C.	1–3			1.70														*			
Rapid City, S. Dak.	29			0.26														*			
Reading, Pa.	24–26			1.23														.21			
Red Bluff, Cal.	26–27			0.68														.15			
Reno, Nev.	21			0.25														*			
Richmond, Va.	1–3			2.03														.19			
Rochester, N. Y.	24–28			2.07														*			
Roseburg, Oreg.	5–7			2.51														.16			
Roswell, N. Mex.	28			T.														T.			
Sacramento, Cal.	26–27			1.20														.34			
Saginaw, Mich.	8			0.31														*			
St. Joseph, Mo.	4			0.21														*			
St. Louis, Mo.	5–6			0.66														*			
St. Paul, Minn.	9			0.08														*			
Salt Lake City, Utah	27			0.30														*			
San Antonio, Tex.	6			0.01														.01			
San Diego, Cal.	26			0.23														*			
Sand Key, Fla.	7			0.69														*			
Sandusky, Ohio.	22–23			0.40														*			
San Francisco, Cal.	4			1.60														*			
San Jose, Cal.	4			1.04														.17			
San Luis Obispo, Cal.	4–5			1.11														.13			
Santa Fe, N. Mex.	21			0.10														*			
Sault Ste. Marie, Mich.	9–10			0.14														*			
Savannah, Ga.	2			0.66														.48			
Scranton, Pa.	24–26			1.97														*			
Seattle, Wash.	5–10			3.72														.19			
Sheridan, Wyo.	29			0.42														*			
Shreveport, La.	22			0.01														*			
Sioux City, Iowa.	4			0.23														*			
Spokane, Wash.	1–2			0.38														*			
Springfield, Ill.	5–6			0.51														*			
Springfield, Mo.	5			0.18														*			
Syracuse, N. Y.	24–28			1.97														*			
Tacoma, Wash.	5–10			4.21														.29			
Tampa, Fla.	24	7:20 a. m.	7:55 a. m.	0.39	7:35 a. m.	7:46 a. m.	.02	.27	.36	.37											
Tatoosh Island, Wash.	13–16			3.89														.32			
Taylor, Tex.	{10, 23, 26}			T.														T.			
Terre Haute, Ind.	12			0.62														*			
Thomasville, Ga.	29			0.61														.60			
Toledo, Ohio.	22–23			0.24														*			
Tonopah, Nev.	21			0.12														*			
Topeka, Kans.	28			0.14														*			
Valentine, Nebr.	27–28			0.16														*			
Vicksburg, Miss.	13	12:46 a. m.	D. N. a. m.	0.59	12:56 a. m.	1:09 a. m.	.06	.24	.32	.38											
Walla Walla, Wash.	1–2			2.18														*			
Washington, D. C.	2–3			1.09														*			
Wichita, Kans.	27			0.06														*			
Williston, N. Dak.	9			0.15														*			
Wilmington, N. C.	13			0.84														.48			
Winnemucca, Nev.	27			0.43														*			
Wytheville, Va.	24–25			1.37														.19			
Yankton, S. Dak.	27–28			0.13														*			
Yellowstone Park, Wyo.	2–3			0.23														*			

[1] Jan. 31.

* Self-register not working.

TABLE III.—*Data furnished by the Canadian Meteorological Service, February, 1916.*

Stations.	Altitude above M. S. L.* Jan. 1, 1916.	Pressure.			Temperature of the air.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea-level reduced to mean of 24 hours.	Departure from normal.	Mean max.+ mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*Inches.*	*Inches.*	*Inches.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F.	125	29.69	29.83	0.00	21.2	−0.8	28.4	14.1	47	−10	6.02	+1.11	22.0
Sydney, C. B. I.	48	29.86	*29.90*	− *.02*	19.4	+0.1	29.9	9.0	46	−25	4.78	+0.69	32.0
Halifax, N. S.	88	29.81	*29.92*	− *.03*	22.3	−0.1	30.5	14.1	48	−14	5.08	−0.08	37.5
Yarmouth, N. S.	65	29.83	*29.91*	− *.08*	23.7	−2.1	30.1	17.3	47	−10	3.94	−0.80	28.4
Charlottetown, P. E. I.	38	29.87	29.91	− .04	16.9	−0.7	25.1	8.8	44	−16	2.61	−0.45	13.4
Chatham, N. B.	28	29.89	*29.92*	− *.04*	13.6	+1.1	23.7	3.6	45	−19	2.51	−0.65	18.2
Father Point, Que.	20	29.87	29.90	− .08	11.2	−0.3	19.3	3.2	38	−17	1.64	−0.57	15.0
Quebec, Que.	296	29.61	29.95	− .04	10.4	−1.4	18.3	2.5	37	−24	2.48	−0.79	21.7
Montreal, Que.	187	29.77	30.00	− .02	11.6	−2.9	18.4	4.7	40	−18	3.76	+0.69	28.1
Stonecliffe, Ont.	489	29.42	*30.06*	− *.05*	6.7	−3.2	19.1	− 5.7	35	−30	1.78	−0.22	17.8
Ottawa, Ont.	236	29.75	*30.10*	+ *.08*	11.6	−0.1	19.4	3.8	42	−18	3.63	+0.94	35.3
Kingston, Ont.	285	29.72	30.06	+ .02	15.0	−2.8	22.8	7.2	41	−16	1.54	−1.00	15.4
Toronto, Ont.	379	29.64	*30.04*	*.00*	18.9	−2.6	26.1	11.8	44	− 9	2.47	−0.14	24.7
White River, Ont.	1,244	28.66	*30.07*	+ *.05*	− 4.4	−4.6	13.6	−22.5	40	−46	0.98	−0.54	9.8
Port Stanley, Ont.	592	29.45	30.12	+ .06	19.6	−3.2	27.1	12.1	38	−15	2.96	−0.25	29.2
Southampton, Ont.	656	29.33	*30.07*	+ *.05*	16.3	−3.6	24.3	8.4	39	−19	2.97	+0.07	29.7
Parry Sound, Ont.	688	29.32	30.06	+ .05	12.0	−2.3	21.0	3.0	36	−24	3.51	+0.59	35.1
Port Arthur, Ont.	644	29.40	30.16	+ .11	5.5	−0.9	17.0	− 6.0	46	−22	0.08	−0.82	0.8
Winnipeg, Man.	760	29.33	30.23	+ .13	1.0	+2.6	10.3	− 8.3	43	31	0.25	−0.73	2.5
Minnedosa, Man.	1,690	28.27	30.21	+ .12	2.6	+5.3	12.8	− 7.5	46	−33	0.33	−0.28	3.3
Qu'Appelle, Sask.	2,115	27.80	30.18	+ .10	5.9	+6.5	15.0	− 3.1	46	−30	0.34	−0.39	3.4
Medicine Hat, Alberta.	2,144	27.76	*30.15*	+ *.10*	16.7	+5.5	26.9	6.5	57	−28	1.21	+0.54	11.5
Swift Current, Sask.	2,392	27.48	*30.21*	+ *.14*	10.1	+2.1	18.8	1.5	48	−28	1.02	+0.28	10.2
Calgary, Alberta.	3,428	26.49	*30.19*	+ *.20*	19.8	+6.3	30.8	8.9	66	−20	0.61	−0.02	6.1
Banff, Alberta.	4,521	25.40	*30.23*	+ *.25*	15.6	−3.6	26.5	4.7	48	−37	0.87	−0.05	8.5
Edmonton, Alberta.	2,150	27.76	*30.16*	+ *.14*	16.7	+8.4	27.4	6.1	57	−26	0.87	+0.20	8.0
Prince Albert, Sask.	1,450	28.50	*30.16*	+ *.06*	5.7	+8.7	17.0	− 5.6	55	−42	0.06	−0.63	0.3
Battleford, Sask.	1,592	28.38	*30.24*	+ *.15*	7.6	+7.5	19.6	− 4.3	50	−33	0.02	−0.35	0.2
Kamloops, B. C.	1,262	28.90	30.25	+ .29	22.4	−5.9	29.0	15.8	50	−20	1.48	+0.69	13.3
Victoria, B. C.	230	29.78	30.04	+ .04	40.0	+0.5	44.8	35.2	59	24	7.03	+2.93	46.4
Barkerville, B. C.	4,180	25.68	30.14	+ .13	17.7	−1.2	26.0	9.5	48	−20	1.12	−1.94	11.2
Hamilton, Bermuda.	151	29.97	30.13	+ .02	66.2	+4.7	66.8	55.6	71	49	5.54	+1.10	.....

*The altitudes given above were furnished by the Director of the Canadian Meteorological Service, Mar. 9, 1916, and refer to cisterns of barometers at the respective stations. Where sea-level pressures and departures are *italicized* new reduction factors are in course of computation.—C. A., jr.

32793—16——4

Chart I. Hydrographs of Several Principal Rivers, February, 1916.

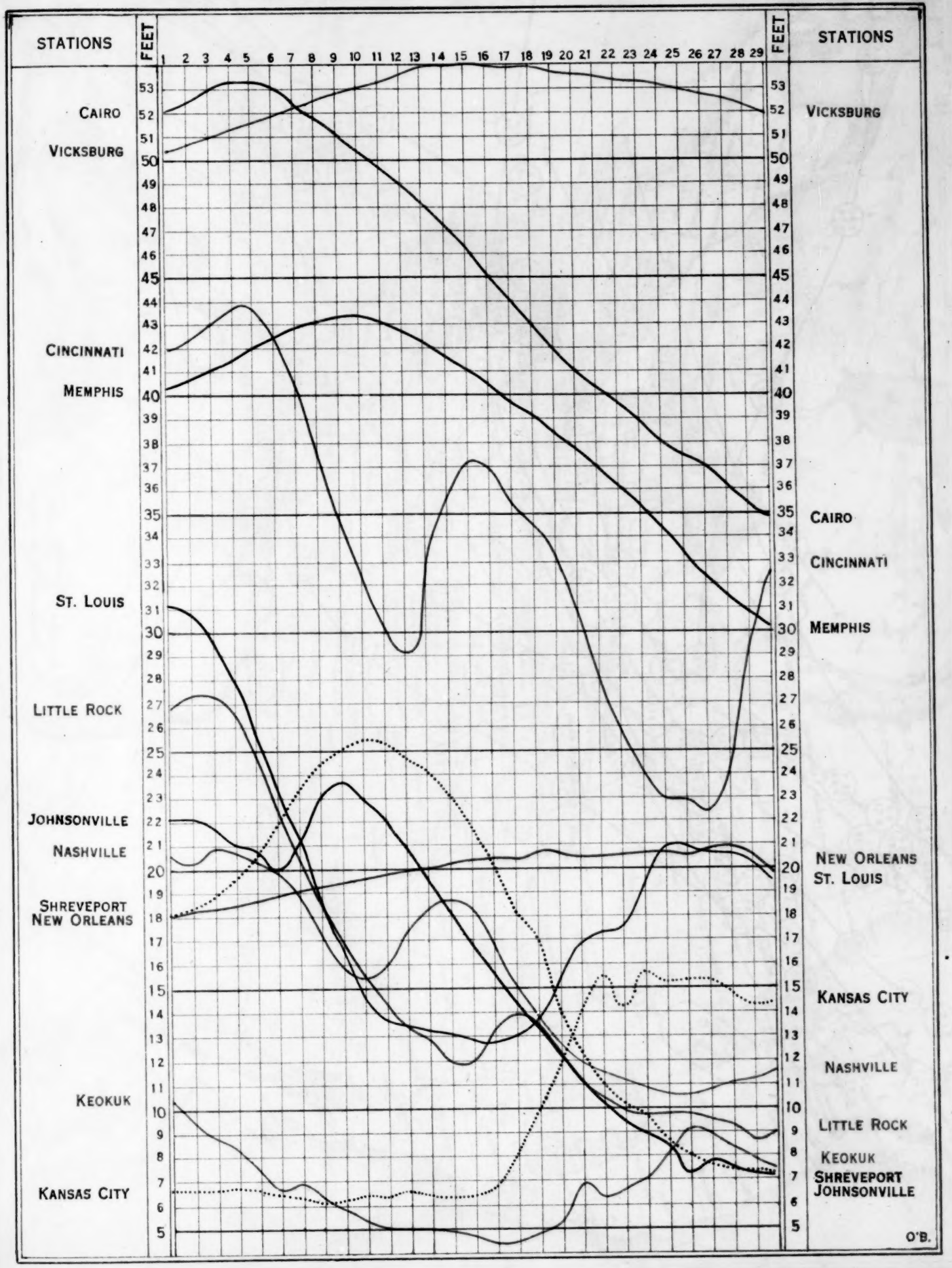

Chart II. Tracks of Centers of High Areas, February, 1916.

(Plotted by R. H. Weightman.)

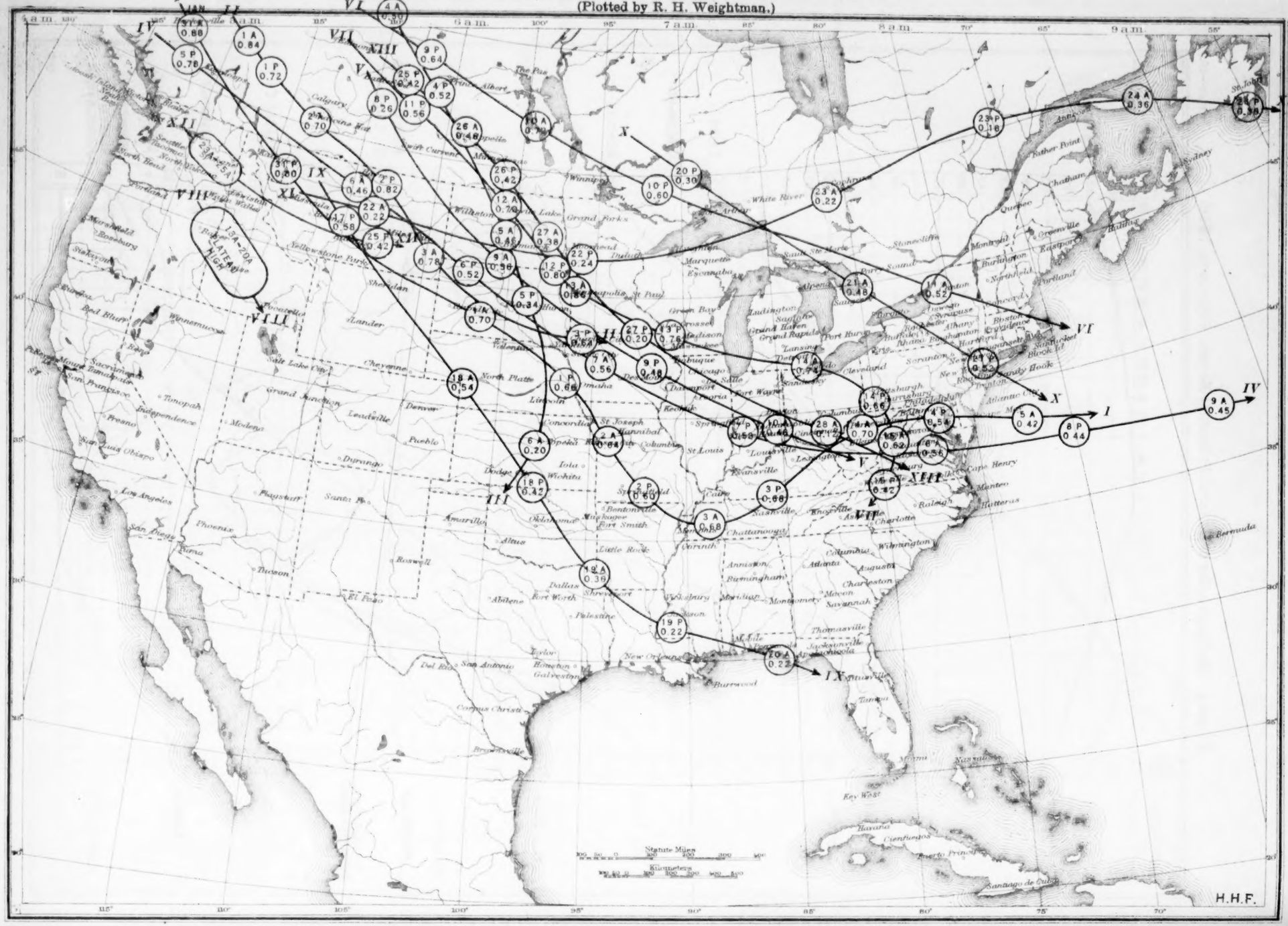

Chart III. Tracks of Centers of Low Areas, February, 1916.

(Plotted by R. H. Weightman.)

Chart III. Tracks of Centers of Low Areas, February, 1916.

(Plotted by R. H. Weightman.)

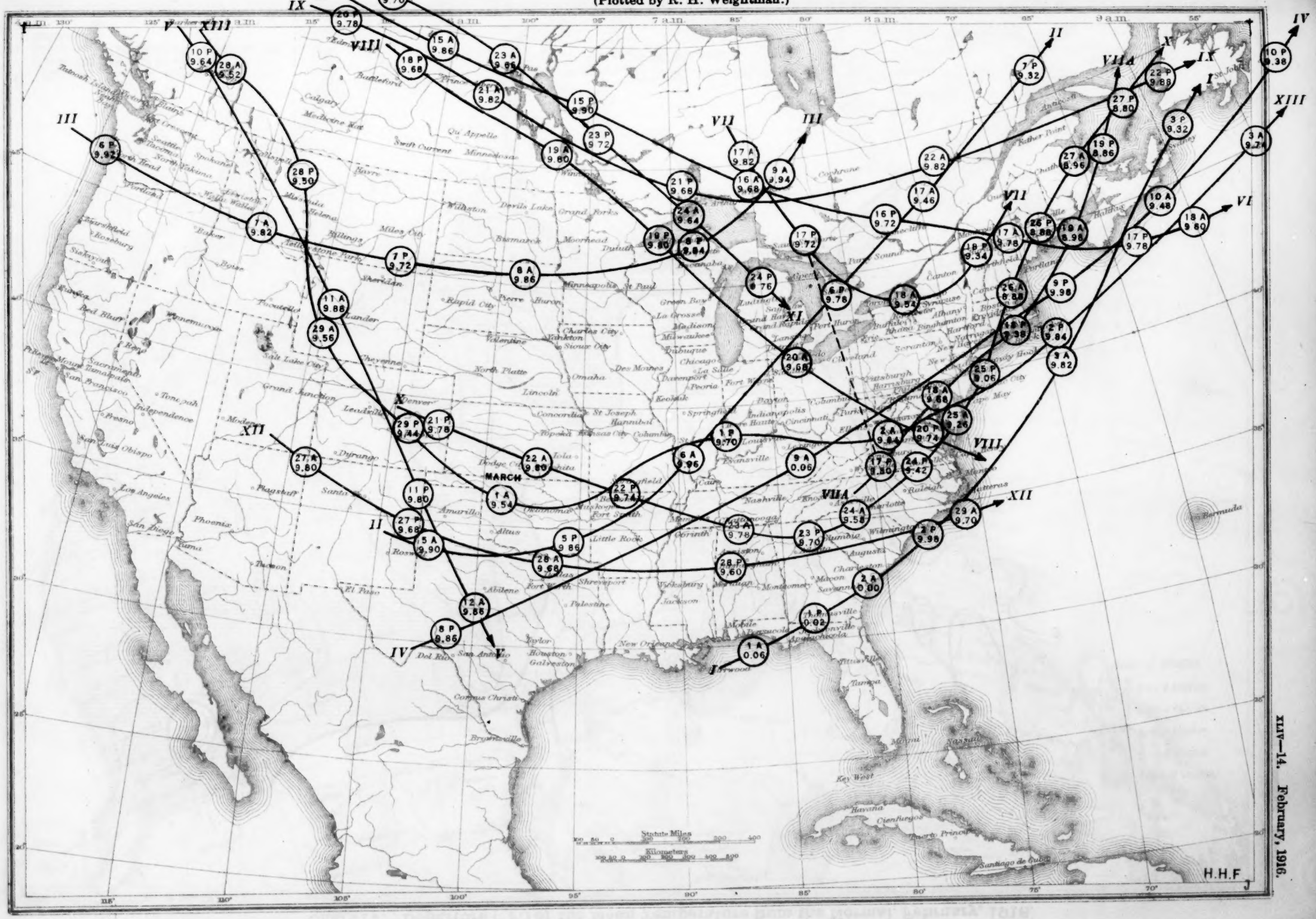

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, February, 1916.

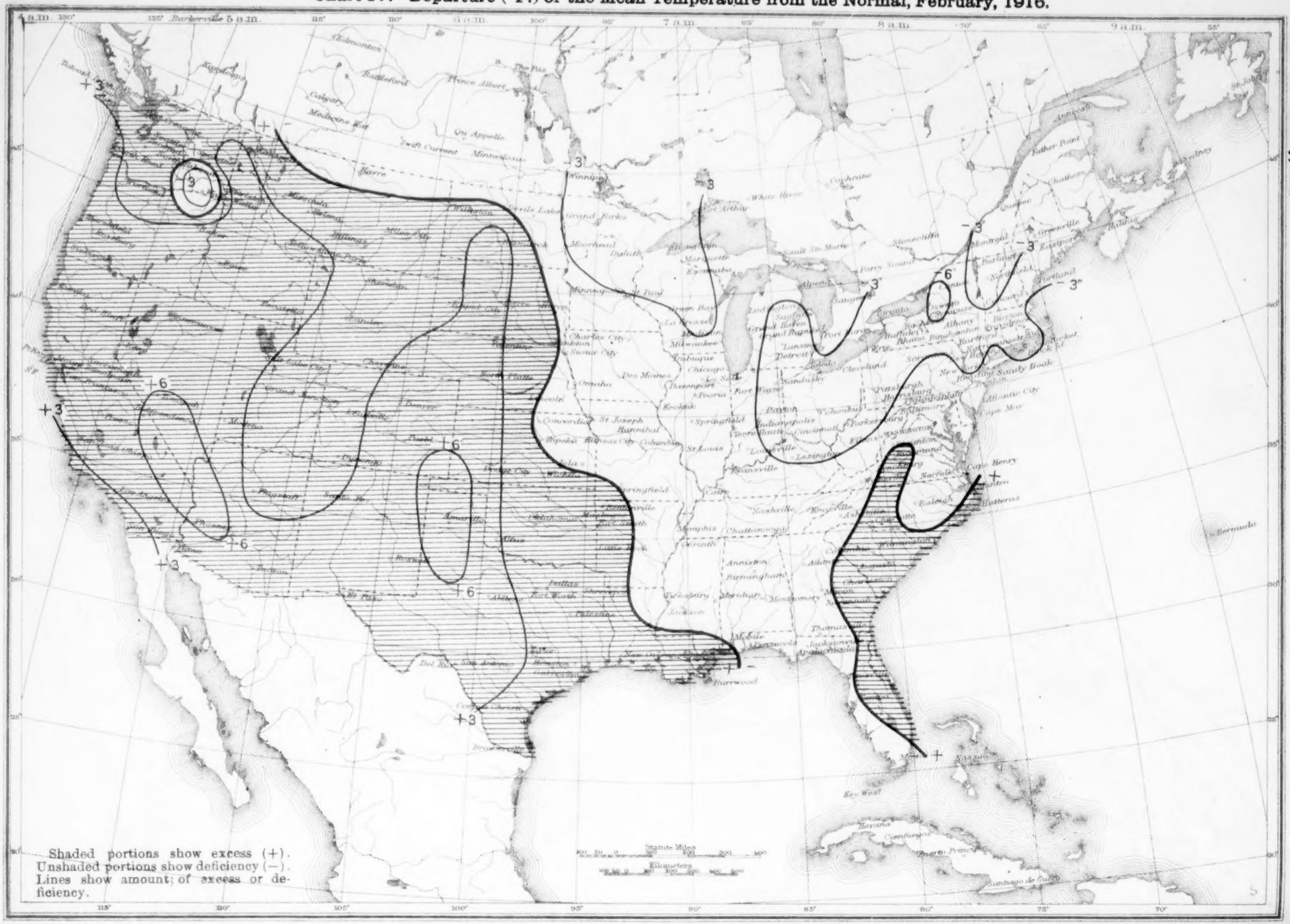

Chart V. Total Precipitation, February, 1916.

Chart V. Total Precipitation, February, 1916.

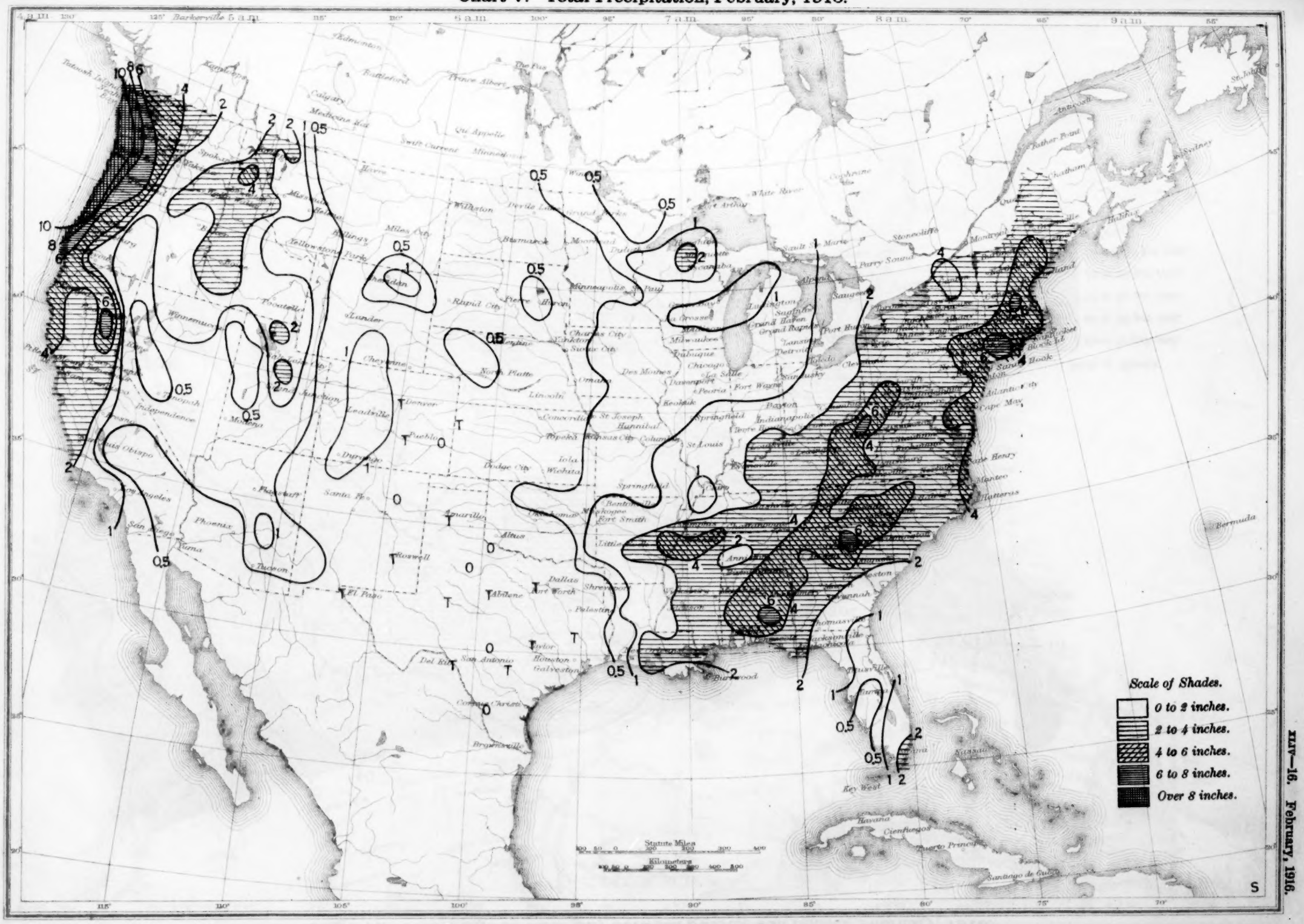

Chart VI. Percentage of Clear Sky between Sunrise and Sunset, February, 1916.

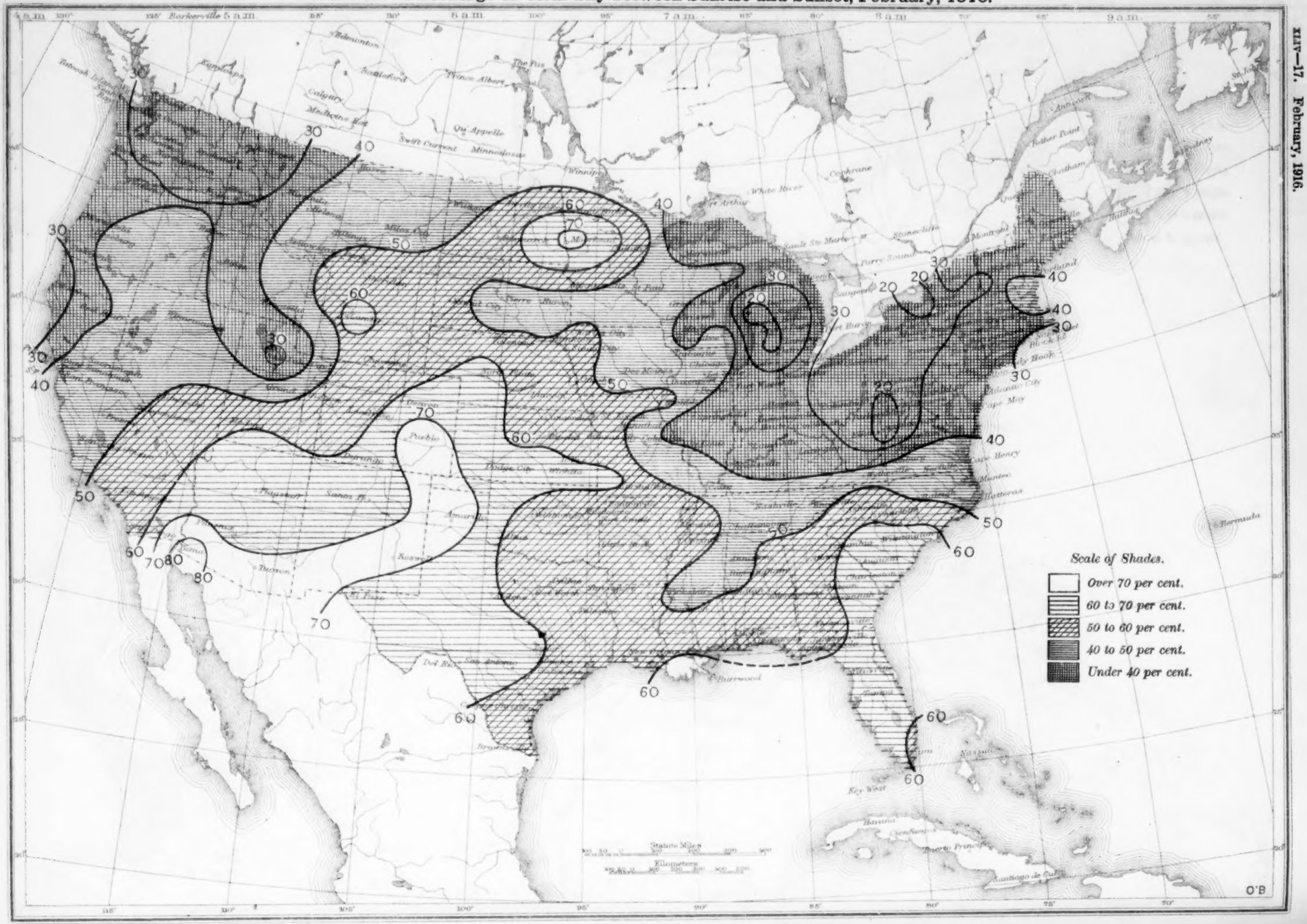

Chart VII. Isobars and Isotherms at Sea Level: Prevailing Winds, February, 1916.

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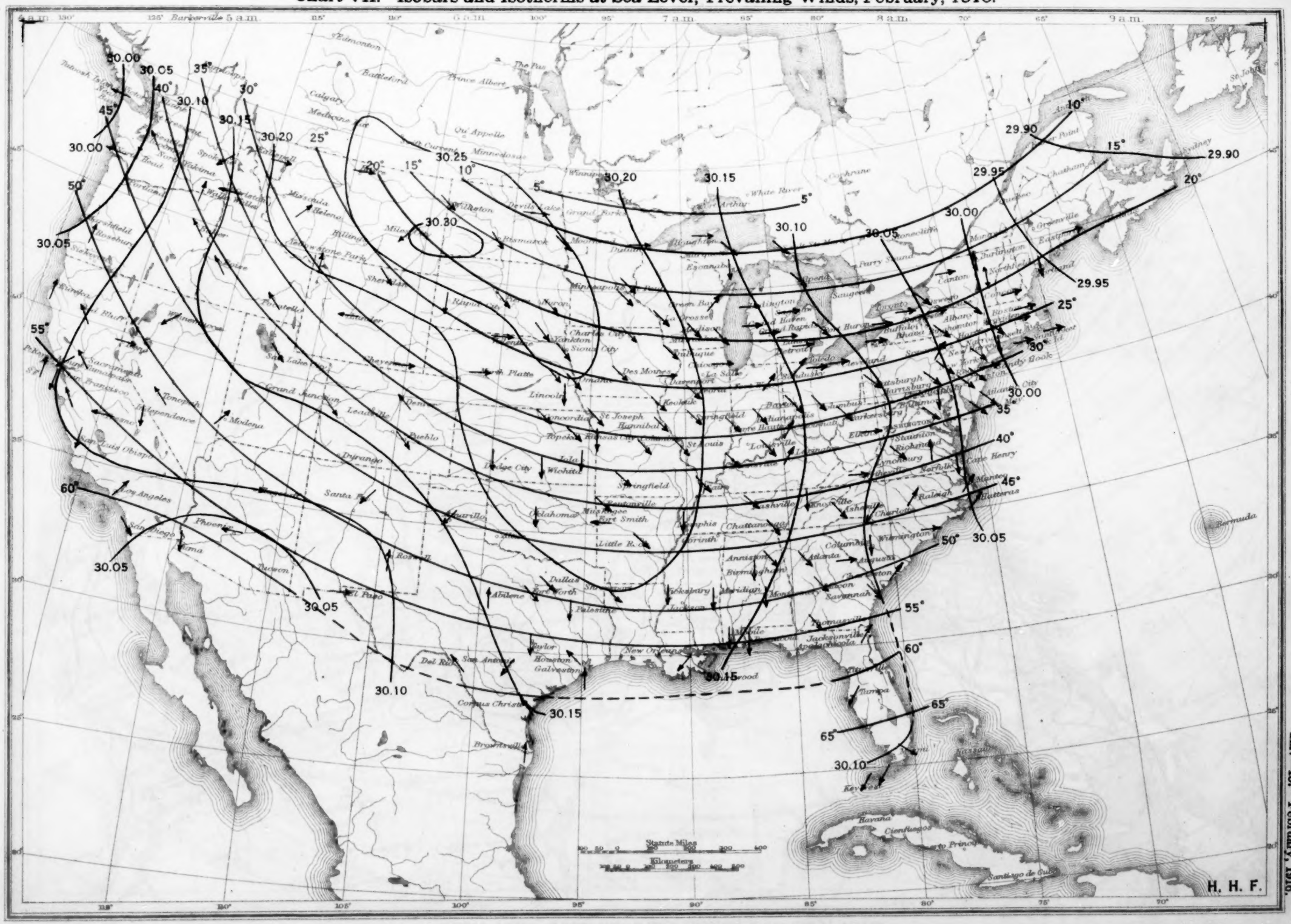


Chart VIII. Total Snowfall, Inches, February, 1916.

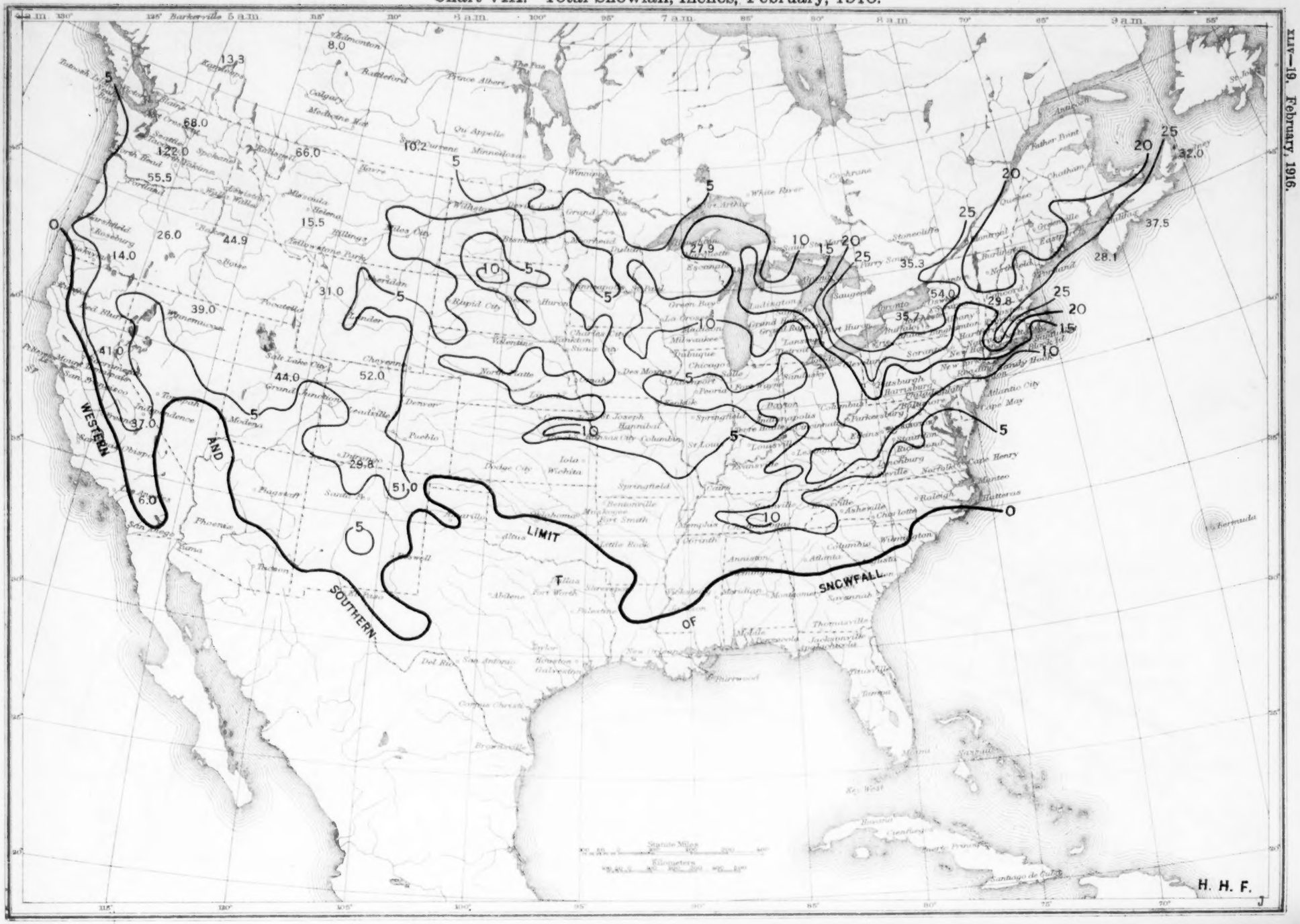


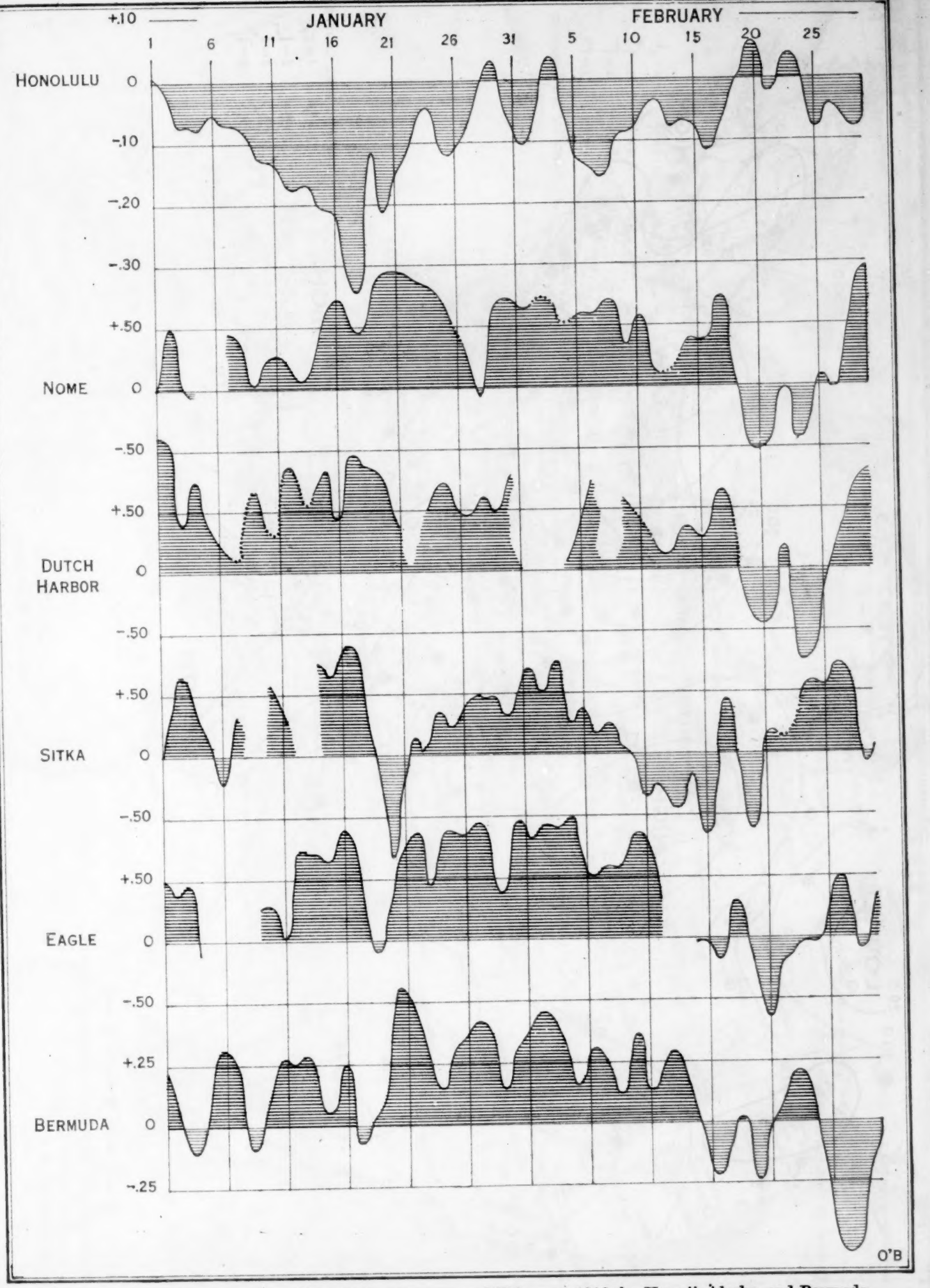
Chart IX. Means of Meteorological Data for North Atlantic Ocean, February, 1915.

Chart IX. Means of Meteorological Data for North Atlantic Ocean, February, 1915.

(Plotted by F. A. Young.)

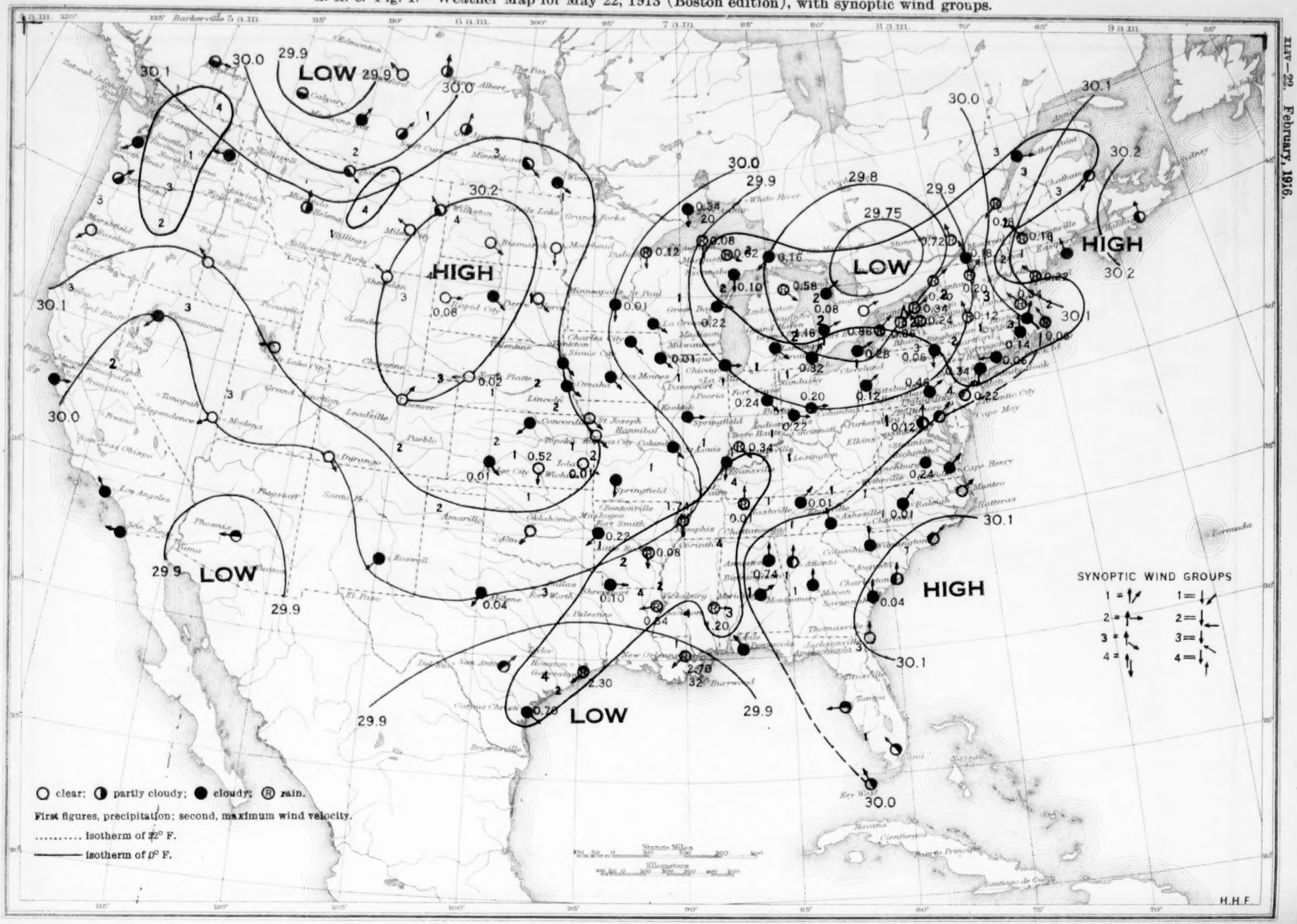
7 a. m., 75th meridian time.
Isobars and prevailing winds in black.
Isotherms and storm tracks in red.

Tropic of Cancer



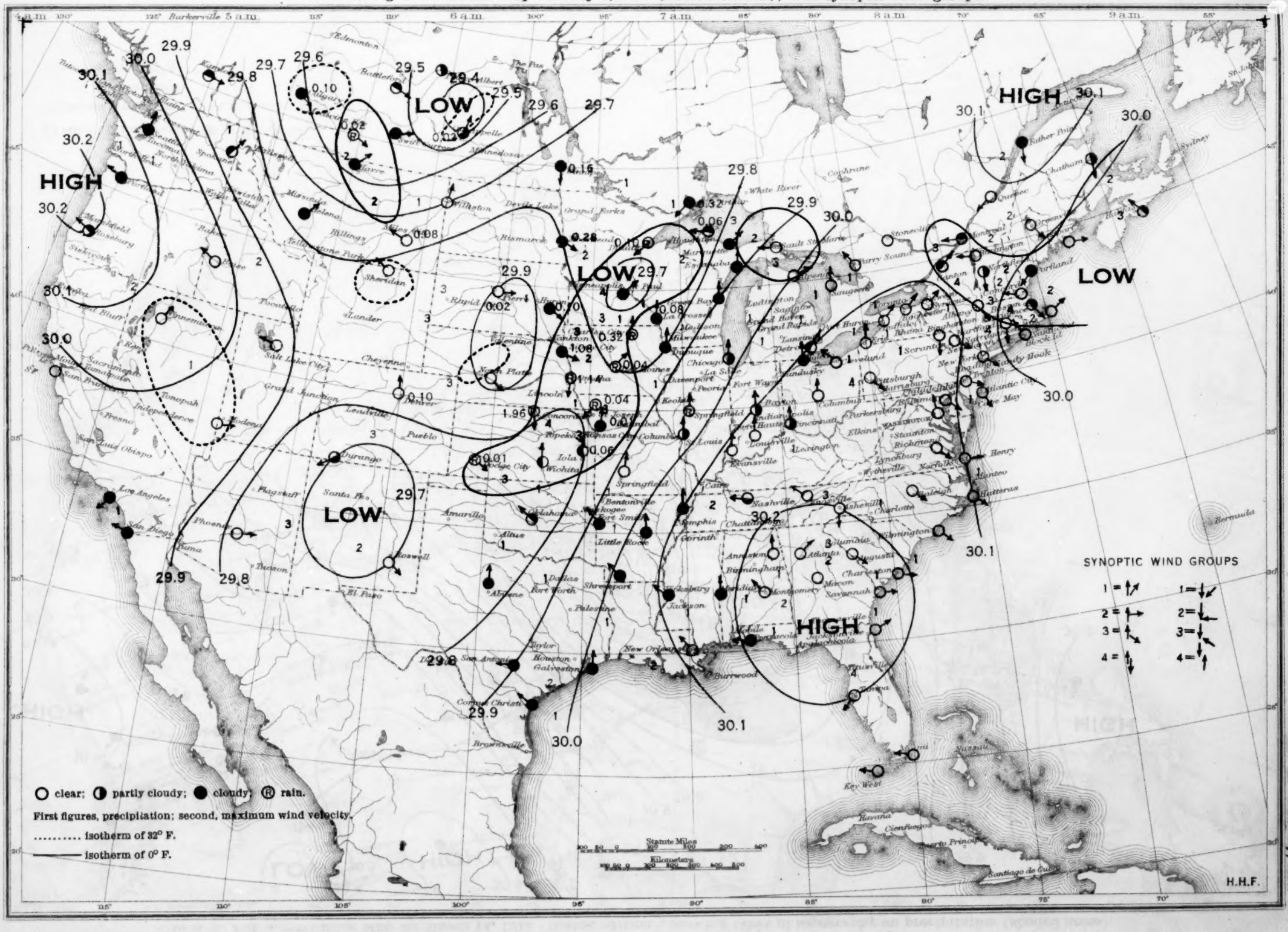
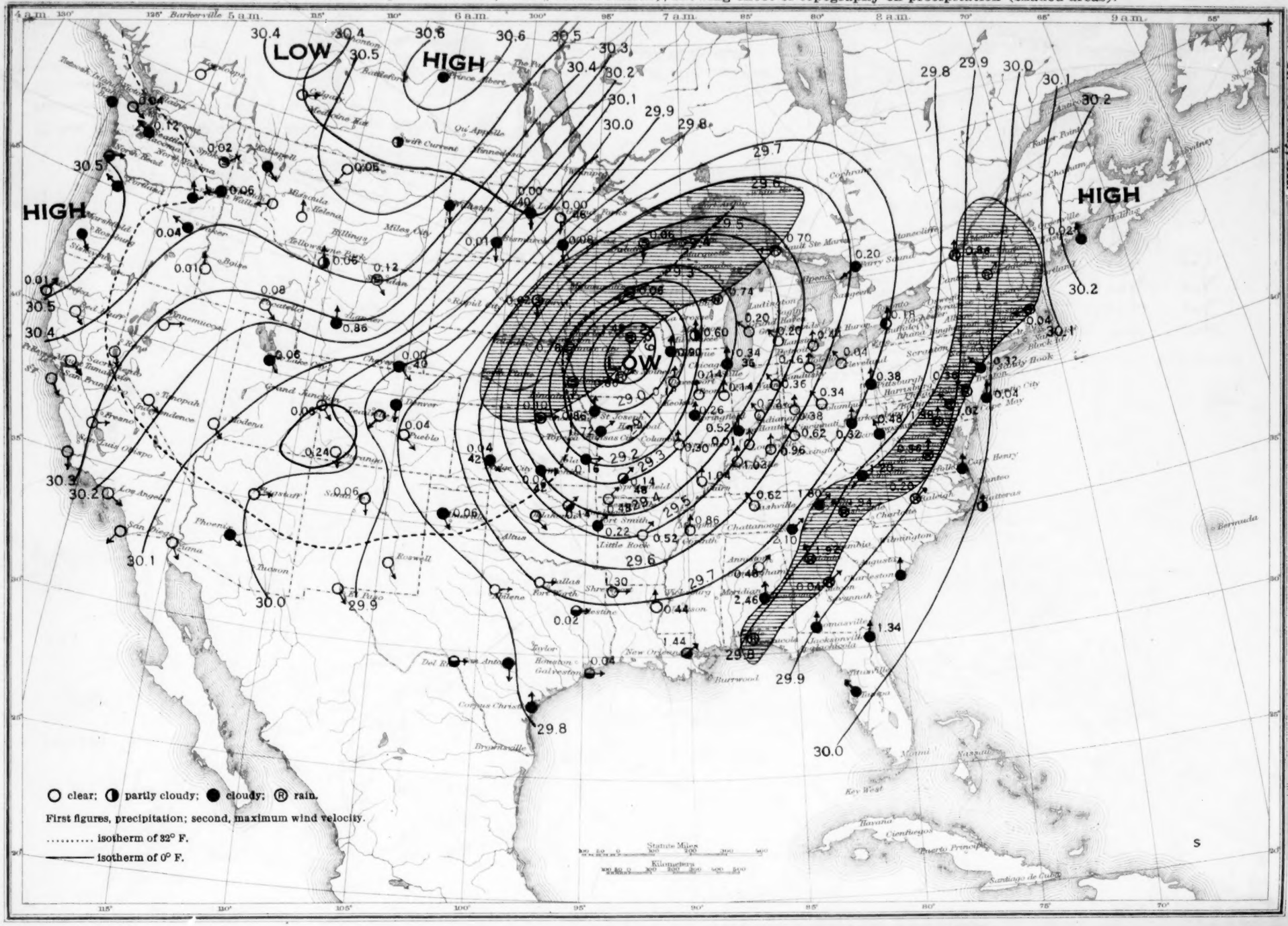
E. H. B. Fig. 1.—Pressure abnormalities during January and February, 1916, for Hawaii, Alaska, and Bermuda.

H. H. C. Fig. 1.—Weather Map for May 22, 1913 (Boston edition), with synoptic wind groups.



H. H. C. Fig. 2.—Weather Map for May 3, 1913 (Boston edition), with synoptic wind groups.

H. H. C. Fig. 2.—Weather Map for May 3, 1913 (Boston edition), with synoptic wind groups.



H. H. C. Fig. 3.—Weather Map for March 14, 1913 (Boston edition), showing effect of topography on precipitation (shaded areas).